DOE/EA - 0413

ENVIRONMENTAL ASSESSMENT FOR 881 HILLSIDE (HIGH PRIORITY SITES) INTERIM REMEDIAL ACTION

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

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LIST OF ACRONYMS

AADI	Adjustable Acceptable Daily Intake
AL	DOE Albuquerque Operations Office
ARARS	Applicable or Relevant and Appropriate Requirements
CA	Cost Analysis
CAA	Clean Air Act
CDH	Colorado Department of Health
CDI	Chronic Daily Intake
CEDE	Committed Effective Dose Equivalent
CEQ	President's Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund)
CFY	Current Fiscal Year
CWA	Clean Water Act
DEHP	bis(2-ethylhexyl)phthalate
DOE	United States Department of Energy
DOT	United States Department of Transportation
EA	Environmental Assessment
EE	Engineering Evaluation
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	Feasibility Study
gpm	gallons per minute
gm	grams
GAC	Granular Activated Carbon
HEA	Health Effects Assessment
HEC	Health Effects Criteria
HS&E	Health, Safety & Environment
IM/IRA	Interim Measures/Interim Remedial Action
JSA	Job Safety Analysis
LCF	Latent Cancer Fatalities
m^3	cubic meters

LIST OF ACRONYMS
(Continued)

mg	milligram
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OSA	Operational Safety Analysis
OSHA	Occupational Safety and Health Administration
pCi	pico Curies
PF	Potency Factor
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
RfD	Reference Dose
RI	Remedial Investigation
SDWA	Safe Drinking Water Act
SWMU	Solid Waste Management Unit
TAD	Total Absorbed Dose
TDS	Total Dissolved Solids
TSCA	Toxic Substances Control Act
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This Environmental Assessment evaluates the impact of an interim remedial action proposed for the High Priority Sites (881 Hillside Area) at the Rocky Flats Plant (RFP). This interim action is to be conducted to minimize the release of hazardous substances from the 881 Hillside Area that pose a potential long-term threat to public health and the environment. This document integrates current site characterization data and environmental analyses, required by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or "Superfund" process, into an environmental assessment pursuant to the National Environmental Policy Act (NEPA).

Characterization of the 881 Hillside Area is continuing. Consequently, a final remedial action has not yet been proposed. The interim remedial action, as described in Section 3.0, does not preclude any subsequent remediation activities.

Environmental impacts associated with the proposed interim remedial action and reasonable alternatives designed to remove organic and inorganic contaminants, including radionuclides, from alluvial groundwater in the 881 Hillside Area are addressed. Although summary descriptions of the interim remedial action and alternatives, including treatment technologies, are included in this document, the reader is referred to the Interim Measures/Interim Remedial Action Plan and Decision Document (DOE, 1990) for detailed descriptions and analyses.

There are three CERCLA documents whose data and analyses are integrated into this Environmental Assessment. These documents are:

1) The Draft Remedial Investigation (RI) Report for High Priority Sites (Rockwell, 1987) at Rocky Flats which was submitted to the Environmental Protection Agency (EPA) and Colorado Department of Health (CDH) on July 1, 1987, in accordance with the schedule set forth in the Compliance Agreement. Results of additional drilling and responses to EPA and CDH comments on the July report were

incorporated into the Final Draft Remedial Investigation Report (Rockwell, 1988c) submitted to the EPA and the CDH on March 1, 1988. The Report provides verification of the existence and location of the high priority waste disposal sites, a characterization of the sites, and an evaluation of the nature and extent of contamination.

2) The Draft Feasibility Study (FS) Report for High Priority Sites (Rockwell, 1988a), was submitted to the EPA and the CDH on March 1, 1988. This report concluded that remedial action was appropriate for the 881 Hillside Area, identified reasonable alternatives, conducted preliminary screening of these alternatives, and selected a preferred remedial action.

3) The Interim Measures/Interim Remedial Action Plan and Decision Document (IM/IRA) for the 881 Hillside Area (DOE, 1990) is being prepared concurrently with this Environmental Assessment. The purpose of the IM/IRA Plan is to provide detailed evaluations on remedial action alternatives identified in the FS in order to support and make modifications to the preferred alternative and to select appropriate treatment technologies to be used in the interim action. The report is being prepared to conform with the requirements for an Engineering Evaluation/Cost Analysis (EE/CA) as defined in the proposed National Contingency Plan [40 CFR 300.415(b)(4)].

1.1 PLANT SITE BACKGROUND

Rocky Flats Plant (RFP) is a federally-owned, contractor-operated facility whose primary mission is the research, development, and manufacture of nuclear weapon components. The complex occupies 6,550 acres on a high plateau in northwest Jefferson County, Colorado, sixteen miles northwest of downtown Denver and ten miles south of downtown Boulder. Operations are confined to 400 acres, with 6,150 remaining acres providing a federally-owned buffer zone surrounding the facility. RFP is administered by the U.S. Department of Energy (DOE).

Rocky Flats Plant began operations in 1951. In the period from 1952 to the present, the plant has fabricated components consisting of plutonium, uranium, beryllium, and stainless steel and has pursued the related activities of chemical recovery and purification of process-produced transuranic radionuclides. Nuclear weapons research and development activities have involved chemistry, physics, materials technology, nuclear safety, and mechanical engineering. Both radioactive and hazardous wastes are generated at RFP.

1.2 881 HILLSIDE BACKGROUND

A comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions is in progress at RFP. These investigations are pursuant to the Compliance Agreement between DOE, the EPA, and CDH dated July 31, 1986. The Agreement addresses hazardous and radioactive mixed waste management at the Rocky Flats Plant.

Hydrogeological and hydrogeochemical characterization on an installation-wide basis was performed at RFP in 1986 as part of the preparation of a RCRA Part B Permit Application. Analysis of this data identified four areas which are the most probable sources of environmental contamination, with each area containing several sites.

The 881 Hillside Area, located at the southeast corner of RFP, was assigned the highest priority of these four areas because of elevated concentrations of volatile organic compounds (VOC) in the alluvial groundwater and the area's proximity to surface drainages, specifically the South Interceptor Ditch and Woman Creek (See Figure 1-1). From 1951 until 1972, portions of the 881 Hillside Area were used as oil sludge pits, chemical burial sites, liquid disposal sites, solvent drum storage sites, and fire damage refuse disposal sites, as well as a disposal area for potentially contaminated asphalt and soil. As a result of these past activities, the soil and groundwater have been contaminated with chemicals identified as posing a potential long-term threat to human health or the environment (see IM/IRA, Section 2.1.6). These practices have been discontinued.

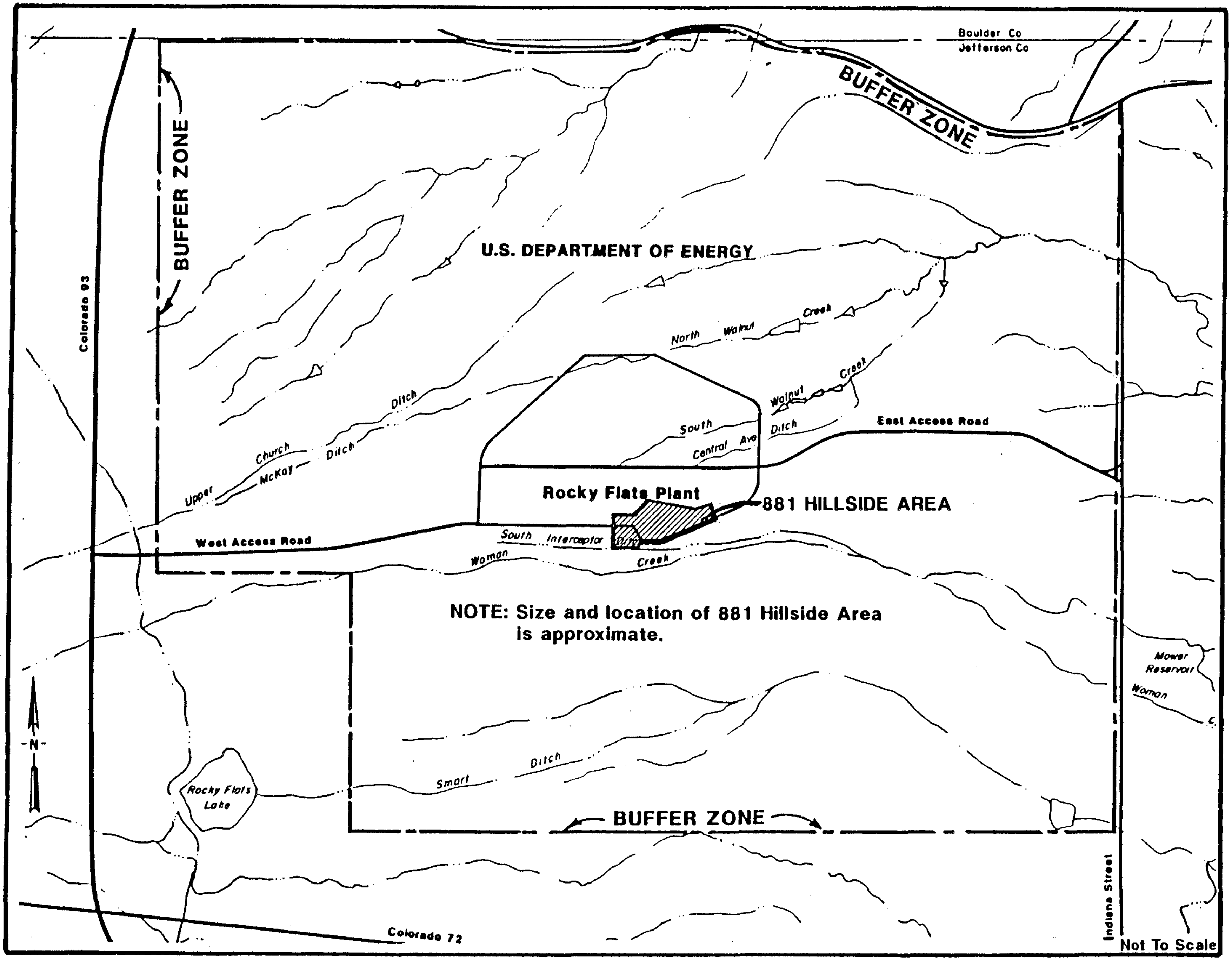
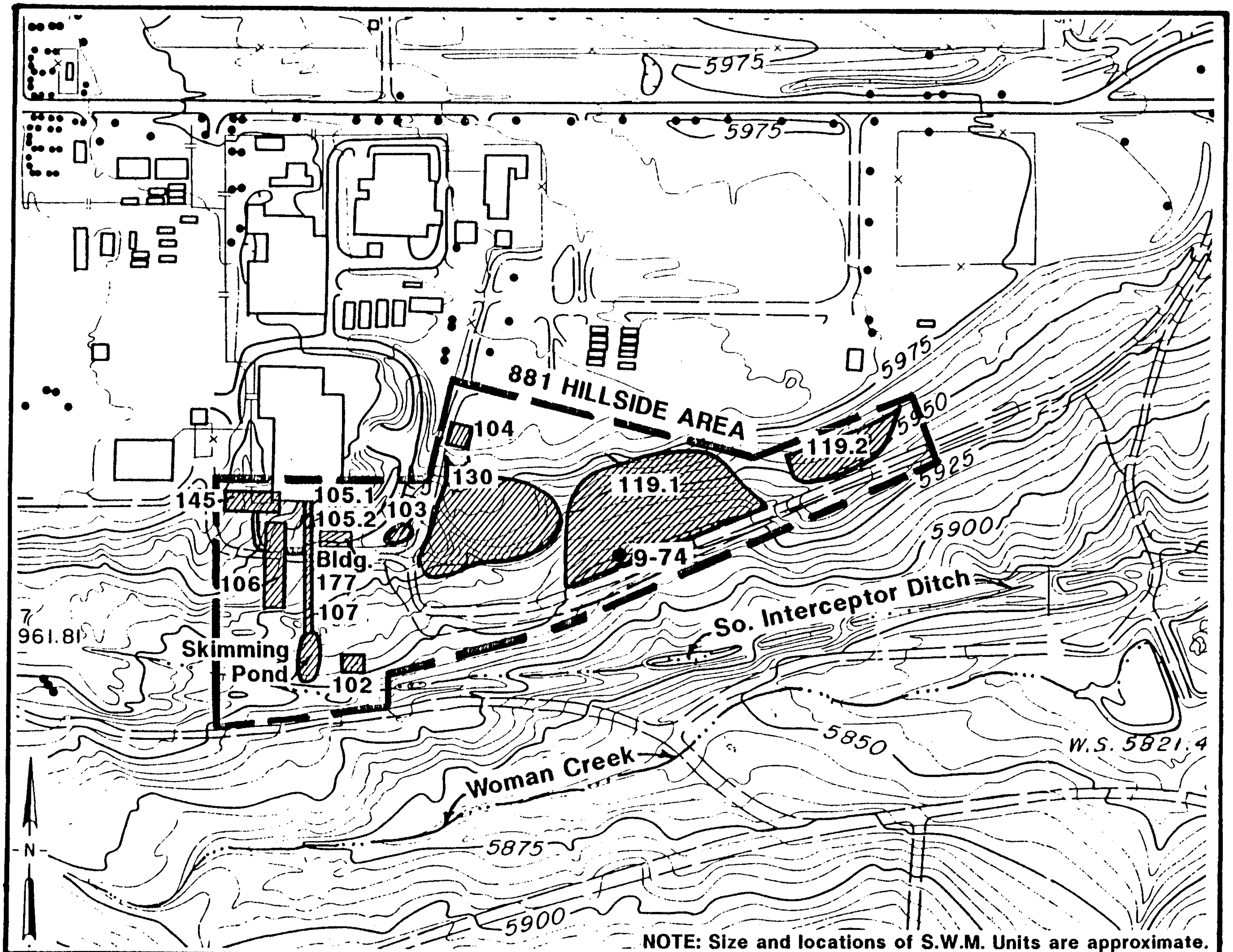


Figure 1-1: SITE LOCATION MAP

Alluvial groundwater at the 881 Hillside Area is characterized by significant VOC contamination. High concentrations of VOCs are notably present in the vicinity of Solid Waste Management Unit (SWMU) 119.1 at Well 9-74 and SWMU 107 at the Building 881 footing drain discharge (Figure 1-2). These groundwaters are also characterized as being above estimated background concentrations of inorganics (few metals, major ions and uranium). Uranium was the only radionuclide occurring at concentrations above the estimated background concentrations.

Downgradient of the 881 Hillside Area, the alluvial groundwater chemistry is characterized by the absence of VOC contamination, with the exception of low concentrations of methylene chloride, acetone, and 1,1-dichloroethene. Downgradient concentrations of inorganic constituents are somewhat lower than at the 881 Hillside Area. Inorganic constituents have apparently migrated from the 881 Hillside Area, but organic contaminants have not migrated to any appreciable extent.

Volatile organic contamination in the soil is not extensive. Uranium and low-volatility organic chemicals, primarily bis(2-ethylhexyl)phthalate (DEHP), have been found.



Scale: 1" = 385'±

Figure 1-2: 881 HILLSIDE AREA SITE MAP

2.0 PURPOSE, NEED, AND SCOPE

2.1 PURPOSE

The purpose of the proposed action is to prevent the release and migration of alluvial groundwater contaminants from the 881 Hillside Area and to reduce existing contamination within the 881 Hillside Area to within acceptable levels, as defined by CERCLA clean-up policy. This effort is to be performed in the interest of protecting public health as well as the environment.

2.2 NEED

Organic and inorganic contaminants exist in the alluvial groundwater beneath the 881 Hillside Area. This contamination is described in detail in the IM/IRA Plan. Table 2-1 was derived from and lists those hazardous materials identified in Chapter 2.0 of the IM/IRA Plan as exceeding "Applicable or Relevant and Appropriate Requirements" (ARARs). In general, there are three categories of potential ARARs at any Superfund site:

- Ambient or chemical-specific requirements which set health- or risk-based concentration limits for hazardous substances or pollutants.

- Locational requirements which set restrictions on activities or limits on contaminant levels, depending on the characteristics of a site and its immediate environment.

- Performance, design, or other action-specific requirements which set controls or restrictions on the management of hazardous substances or pollutants.

A detailed discussion of ARARs relevant to the interim remedial action at the 881 Hillside Area is presented in Section 3.3 of the IM/IRA Plan.

There is no immediate threat to the public health and the environment posed by the groundwater contamination at the 881 Hillside Area because affected

Table 2-1
Hazardous Chemical Concentrations

Hazardous Chemical	Alluvial Groundwater[6] (mg/l) Average	Alluvial Groundwater[6] (mg/l) Maximum	Soil[7] (mg/kg) Average	Soil[7] (mg/kg) Maximum
Organics				
Bis-(2-ethylhexyl)phthalate	NR[1]	NR	1.24 E+0	7.21 E+0
Carbon Tetrachloride	4.60 E-1[2]	2.80 E+1	8.00 E-3	8.00 E+0
E-31,2-Dichloroethane	1.59 E-1	1.60 E+1	8.00 E-3	1.00 E-2
1,1-Dichloroethene	2.30 E+0	4.80 E+1	8.00 E-3	8.00 E-3
t-1,2-Dichloroethene	NR	NR	8.00 E-3	1.80 E-2
Tetrachloroethene	9.46 E-1	1.32 E+1	1.30 E-2	1.90 E-1
Trichloroethene	2.89 E+0	7.20 E+1	1.10 E-2	1.50 E-1
1,1,1 Trichloroethane	1.92 E+0	3.03 E+1	NR	NR
Chloroform	5.00 E-3	5.10 E-2	NR	NR
1,1 Dichloroethane	2.80 E-2	3.50 E-1	NR	NR
1,1,2 Trichloroethane	2.13 E-1	1.47 E-1	NR	NR
Metals				
Manganese	2.41 E-1	9.59 E-1	NR	NR
Mercury	3.00 E-1	9.00 E-1	NR	NR
Nickel	1.90 E-1	8.64 E-1	1.30 E+1	7.10 E+1
Selenium	5.96 E-1	3.20 E+0	4.90 E-1	4.90 E-1
Uranium (total)				
Groundwater	5.12 E+0 (32 pCi/l)[4]	9.95 E-2 (56 pCi/l)	NA[3]	NA
From core borings	NA	NA	3.14 E+0 (2.13 pCi/gm)	6.73 E+0 (4.56 pCi/gm)
Surface soils[5]	NA	NA	390 pCi/gm	4480 pCi/gm
Plutonium				
Surface soils[8,5]	NA	NA	1.63 pCi/gm	4.8 pCi/gm

1 NR = Contamination not reported above minimum detection limit in any on-site sample from this medium.
2 4.60 E-1 = 4.60 x 10^{-1} = 0.46
3 NA = Not Applicable
4 Total Uranium expressed in radiological units. pCi/l = picocuries per liter.
5 From enclosure (1) to Rockwell letter 881HS-1 dated 9-1-88.
6 From Interim Remedial Action Plan (maximum of values in Table 2-1, 2-2, and 2-3) for 881 Hillside Area unless otherwise indicated.
7 From Feasibility Study Report for High Priority Sites (881 Hillside Area), Table 4-1, unless otherwise indicated.
8 Not above ARARs. Included for reference only.

water is contained within the plant boundary (see IM/IRA, Section 2.3). However, an unacceptable risk could be posed to the public should this contamination migrate downgradient of the 881 Hillside Area and enter surface waters of Woman Creek and the South Interceptor Ditch.

2.3 SCOPE OF THE ENVIRONMENTAL ASSESSMENT

This Environmental Assessment (EA) has been prepared pursuant to the National Environmental Policy Act (NEPA) of 1969, as implemented by regulations promulgated by the President's Council on Environmental Quality (CEQ) and DOE Guidelines. It is intended to provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement or a Finding of No Significant Impact for the proposed interim remedial action at the 881 Hillside Area. The following are examined:

1) The environmental impact of the proposed action, which consists of: collection of alluvial groundwater from identified sources, installation of a french drain, treatment of the groundwater to attain or exceed all ARARs, and surface discharge of treated effluent.

2) The environmental impact of the following alternatives:
   a) No action
   b) Total encapsulation
   c) Source well and footing drain collection with treatment
   d) Comprehensive well array and treatment
   e) French drain and soil flushing
   f) Immobilization
   g) French drain and partial excavation

The alternatives were selected to be representative of reasonable alternative actions as determined in the Feasibility Study Report for the 881 Hillside Area.

The scope of the assessment does not include evaluation of the existing operations at the Rocky Flats Plant, final remedial actions at the 881 Hillside Area, or subsequent remedial actions at other locations of the Rocky Flats Plant. The environmental impacts of plant operation were analyzed in the final Environmental Impact Statement (DOE, 1980). NEPA documentation for final remedial actions at the 881 Hillside Area and subsequent remedial actions at other locations of the Rocky Flats Plant will be provided as appropriate.

The total estimated cost of the proposed action is approximately $2 million in capital cost, with approximately $300,000 per year in operating costs over the 30-year life of the operation.

3.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

The proposed action consists of collecting contaminated alluvial groundwaters from three sources within the 881 Hillside Area, pumping this water to a newly constructed treatment facility, and processing and discharging it to the surface (see IM/IRA, Sections 4.5.1 and 6.0). The three collection points will be: a new source well in the vicinity of Well 9-74, a new foundation outfall sump at the existing foundation drain, and a french drain to be constructed across the base of the 881 Hillside Area. The treatment facility will destroy organic contaminants using an ultraviolet peroxide oxidation system and remove inorganic contamination with an ion exchange system. The treated effluent will be discharged into the South Interceptor Ditch upstream of Pond C-2. Pond C-2 will be discharged in full compliance with the NPDES permit into a natural drainage which flows offsite into Standley Lake.

A new source well will be installed near the existing sample well 9-74, which has yielded the most heavily contaminated groundwater samples taken from SWMU 119.1. The purpose of this source well is to remove a local concentration of contaminants without waiting for them to migrate to the drain, thus shortening the remediation period.

The SWMU 107 footing or foundation drain has functioned effectively for thirty years in lowering the water table near the Building 881 foundation. A precast concrete sump will be placed beneath the outfall. Submersible pumps and underground piping will be installed to carry the collected groundwater to the treatment facility. Electrical lines will be installed to provide power to the pumps.

A trench, approximately 2,100 feet long, will be constructed downgradient of the alluvial groundwater contamination plume, across the base of the 881 Hillside (see Figure 3-1). The trench will extend from the soil surface to the bedrock. An impermeable membrane on the downgradient side of the trench will provide positive cutoff of groundwater flow. A french drain consisting of porous plastic pipe embedded in drain rock will be installed prior to backfilling

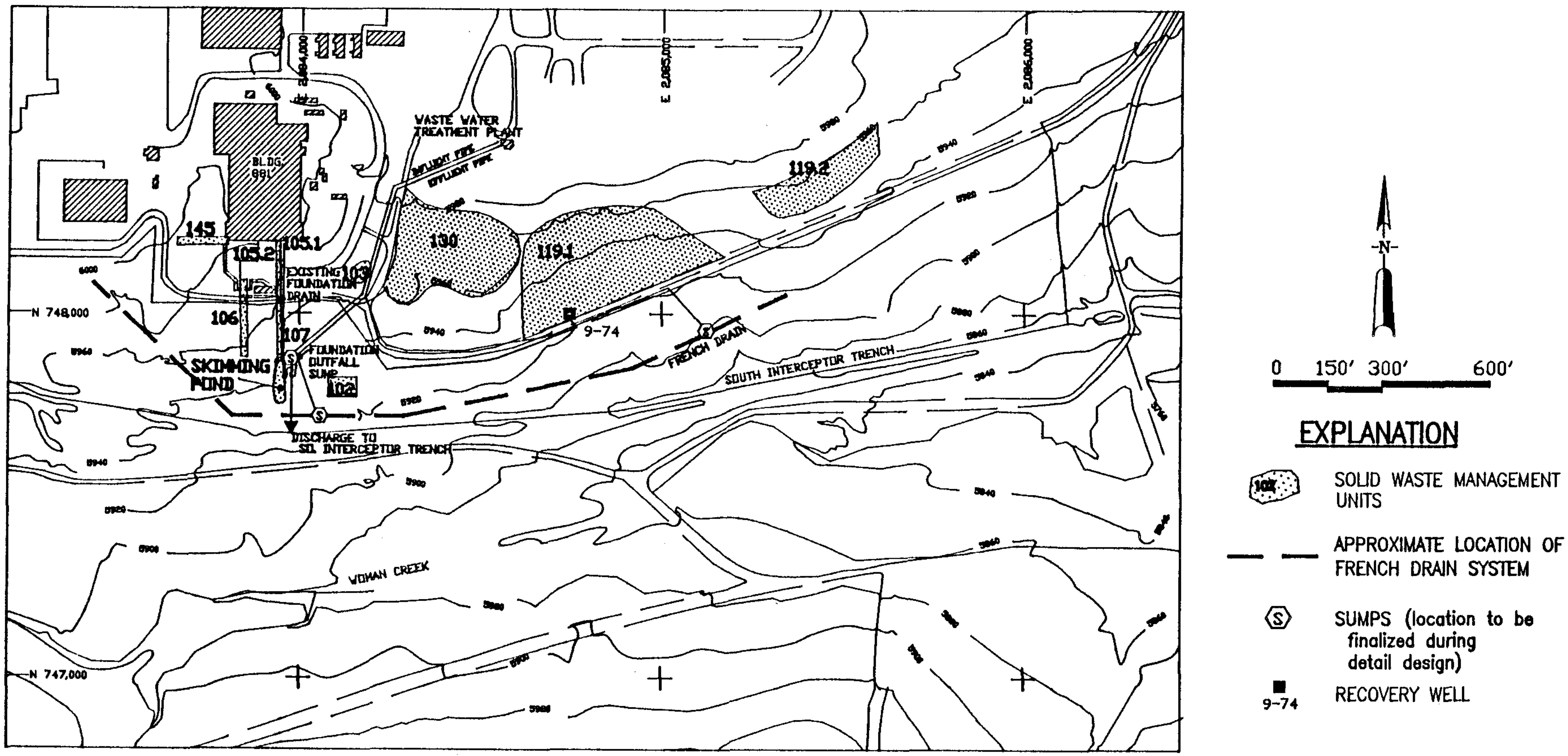


FIGURE 3–1

PROPOSED INTERIM REMEDIAL ACTION
FRENCH DRAIN COLLECTION
WITH TREATMENT

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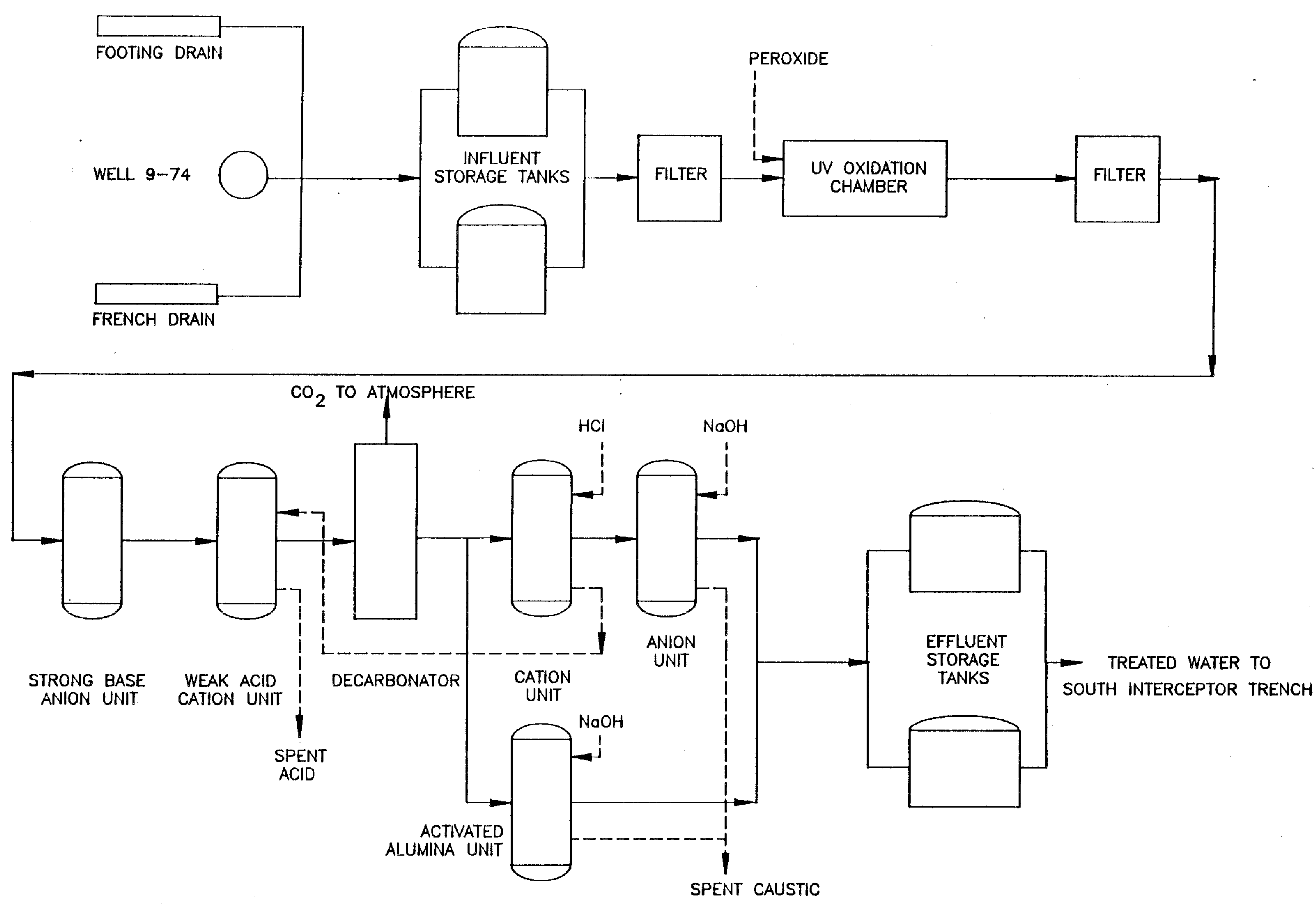

FIGURE 3-2 – TREATMENT SYSTEM PROCESS FLOW DIAGRAM

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to collect the groundwater. A filter fabric will be placed on the upgradient side and the bottom of the trench to minimize clogging. Two 3-foot diameter collection sumps will gather alluvial groundwater, and submersible pumps will transfer the water to the treatment facility through buried piping. French drains have been successfully used for many years in the containment and collection of contaminated groundwater. The french drain proposed in this alternative is designed to be keyed into a low permeability bedrock and backed up with a downstream, impermeable liner. This collection system is expected to effectively contain all alluvial groundwater flow from the 881 Hillside Area. The useful life of the french drain system is expected to be at least thirty years. Clogging is not expected to be a problem based on past experience of the footing drain at Building 881, which has been in service since the 1950's.

A treatment facility will be constructed east of Building 881 (see Figure 3-1). Two 15,000-gallon influent tanks and two 115,000-gallon effluent tanks will be placed on a pad adjacent to the treatment facility. A two-step treatment process is proposed, which effectively destroys volatile organic chemicals without prior concentration and removes dissolved inorganic chemicals. Figure 3-2 is a simple flow diagram of the treatment system.

The IM/IRA Plan (Section 4.3.1 - 4.3.3) for the 881 Hillside Area evaluated three groundwater treatment technologies for the removal of organic compounds: 1) granular activated carbon (GAC) adsorption, 2) ultraviolet (UV)/peroxide oxidation, and 3) air-stripping with off-gas treatment. The effectiveness, implementability, and costs of these technologies were analyzed and the UV/peroxide oxidation system was selected.

The advantage provided by a UV/peroxide oxidation system is its direct destruction of the volatile organic groundwater contaminants, which was the deciding factor in the selection of this system as the preferred treatment process. It is a simple system made up of an 80-gallon reaction tank, ultraviolet lamps, a small hydrogen peroxide feed tank, small capacity pumps, and piping. A detailed description of this system and the selection process can be found in the IM/IRA Plan (Section 4.3.2).

The following text provides a summary of the construction and operational phases of the alternatives retained for the Environmental Assessment. A generalized comparison of each alternative's environmental impacts to those of the proposed action is presented in Section 6.1 of this document.

3.2.1 No Action

Semi-annual monitoring of ground and surface water conditions would be pursued over a thirty-year period or until concentrations of volatile organic contaminants drop below detectable limits due to natural dilution or other material removal processes. This alternative does not collect, contain, or remove the contaminants identified at the site. Therefore, if contaminants were to appear in pathways that could cause off-site exposures, other alternative actions would have to be initiated at that time.

3.2.2 Total Encapsulation

A multilayered cover (RCRA Cap) and soil-bentonite slurry walls keyed into the claystone bedrock would provide contaminant containment and groundwater diversion. Pre-existing and intrusive groundwater would be periodically removed by a new sump and submersible pumps located within the encapsulated area, transported by tank truck, and treated at an existing on-site wastewater facility.

3.2.3 Source Well and Footing Drain Collection with Treatment

As in the proposed action, contaminated groundwater would be collected from a source well at SWMU 119.1 and a new sump at the existing SWMU 107 footing drain outfall, piped to a new treatment facility to be located east of Building 881, and the treated effluent surface-discharged into the South Interceptor Ditch. Unlike the proposed action, no french drain will be utilized to collect alluvial groundwater.

The IM/IRA Plan (Section 4.3.4 - 4.3.6), using the same criteria, evaluated three groundwater treatment technologies for the removal of inorganic contaminants: 1) electrodialysis, 2) ion exchange treatment, and 3) reverse osmosis. A multiple-stage, ion exchange treatment system was selected because this system is considered to be more reliable for long-term operation and because no supplemental water source is required. In the first stage, over 99% of the uranium is removed using a strong basic resin. Subsequently, ion exchange stages will remove heavy metals, total dissolved solids (TDS), and selenium.

The strong basic unit, which will remove uranium from the groundwater, will not be regenerated. Instead, the unit will be shipped off-site and disposed of as a low-level radioactive waste when its activity reaches a predetermined level. This unit is expected to operate for more than thirty years before reaching this level. The regenerant wastes from the other ion exchange resins will be sent to Building 374 for final treatment. By placing the UV/peroxide oxidation unit before the ion exchange units, the organic contaminants are destroyed first. The purpose of this design is to eliminate organic contaminants from the waste stream sent to Building 374. Such contaminants would be in violation of the RCRA Part B Permit requirements.

Treatment plant effluent will meet all chemical-specific ARARs and will be discharged to the South Interceptor Ditch. The point of discharge will be at the west end of the 881 Hillside Area (upstream) and the discharged water will flow along the ditch to Pond C-2.

3.2 ALTERNATIVES FOR ENVIRONMENTAL ASSESSMENT EVALUATION

Seven interim action alternatives, including No Action, were considered in the Feasibility Study Report (Section 3.3) as representative of the range of appropriate approaches to remediation of the 881 Hillside Area. The alternatives were examined as required by the NEPA regulations, which state that an agency shall "Study, develop, and describe appropriate alternatives to recommended course of action. . ." (40 CFR 1501.2(c) (1987)).

3.2.4 Comprehensive Well Array and Treatment

In place of the proposed action's french drain, a line of dewatering wells would be installed at the base of 881 Hillside to collect all groundwater flows passing through the contaminated areas. The wells would feed a collection header, whose flow would be added to flows from the SWMU 119.1 source well and the SWMU 107 footing drain collector and piped to a new treatment facility, similar to the proposed action. Treated effluent would then be discharged to the surface similar to the proposed action.

3.2.5 French Drain and Soil Flushing

To speed the removal of contaminated liquids in the soils of SWMU 119.1, a leach field would be added to the proposed action to implement soil flushing. A portion of the treatment plant's effluent would be diverted to the leach field which would be located in the uphill section of SWMU 119.1. The treated effluent would leach into the soils, displacing the contaminated liquid downwards towards the source well and french drain. Soil flushing might result in a time savings in remediation over the proposed action. Such soil flushing could be added to the proposed remedial action in the future if experience with the proposed action indicated a need to accelerate the cleanup. The addition of soil flushing would, however, involve more excavation to provide an effective leach field.

3.2.6 Immobilization

A polymer grout, introduced through 460 injection wells, would be used to divert groundwater flow around the area containing the already contaminated groundwater and to physically immobilize the contaminants in place. No removal of groundwater or soil would be involved. A ground and surface water monitoring program would measure the system's performance.

3.2.7 French Drain and Partial Excavation

This alternative action is similar to the proposed action. However, the remediation period would be reduced through the excavation of 3,000 cubic yards of soil from a circular area centered on the SWMU 119.1 source well.

are sized to accommodate the one-hundred-year storm event depositing four inches of water in a six-hour period.

Mineral resources occurring in the vicinity of RFP include sand, gravel, crushed rock, clay, coal, and uranium. There are no clay, coal or uranium deposits within the RFP boundary; however, these commodities are mined in the region, within twenty miles of the plant. Active sand and gravel mines lie within the buffer zone boundaries. There is a currently inactive aggregate processing facility adjacent to the northwest corner of the buffer zone. The facility is scheduled to be reopened in 1989. Oil and natural gas production is also active away from the plant site in northwest Adams County and east central Boulder County.

There are four main drainages from the plant property: North Walnut, South Walnut, Rock and Woman Creeks. All are intermittent streams which provide drinking water and irrigation water. There are a number of ditches crossing the area as well, conveying water collected off-site to other areas, the Plant, Walnut Creek, or Woman Creek. Until late 1974, plant waste water had been discharged to Walnut Creek, and until 1975, filter backwash from the raw water treatment plant went into Woman Creek. All process waste water is now disposed of through evaporation and recycling on-site. Sanitary waste water is discharged in accordance with the National Pollutant Discharge Elimination System (NPDES) permit effluent limitations when on-site spray irrigation is not feasible.

The groundwater present at the 881 Hillside is in surficial materials under unconfined conditions. Recharge to the water table occurs as infiltration of incident precipitation and as seepage from ditches and creeks. The shallow groundwater flow system is quite dynamic, with large water level changes occurring in response to precipitation events and to stream and ditch flow. Flow through colluvial materials appears to primarily occur in the gravel within the colluvium. At the Rocky Flats terrace edges, groundwater emerges as seeps and springs at the contact between the alluvium and claystone bedrock (contact seeps), is consumed by evapotranspiration, or flows through colluvial materials following topography toward the valley fill and terrace alluviums. Once

4.0 POTENTIALLY AFFECTED ENVIRONMENT

4.1 DESCRIPTION

Rocky Flats Plant is located in rural Jefferson County, six miles from the nearest school and ten miles from the nearest hospital. Immediate neighbors are agricultural and industrial operations with few residents. There are five industrial facilities within five miles of RFP and several ranches within ten miles of the facility. The nearest residence and domestic water well is greater than 1.2 miles, the distance from the 881 Hillside Site to the RFP boundary. To the southeast, growth in the northwest Denver suburbs has pushed development in the RFP's direction. Residential subdivisions exist within two miles of the buffer zone boundary. The buffer zone insures that, other than at the plant and selected industrial sites, no development can occur within 1.6 miles of the contaminated source areas. In the twenty years from 1980-2000, the number of residents within five miles of RFP is expected to more than double, from 9,500 to 20,000 (DOE, 1990, Section 2.1.3).

The name Rocky Flats refers to the five-mile wide terrace of cobbly alluvium on which the facility sits. The terrace surface, at about six thousand feet in elevation, was built up from the sedimentary bedrock by deposits from the weathering of the adjacent mountains. The result is a wide, rock-covered flat which slopes east from the base of the foothills of the Front Range. Technically, the area is the western edge of the Denver Basin in the Great Plains Tectonic Province. This is a tectonically stable region, classified as Seismic Zone 1, indicating a minor potential for earthquake damage. The foothills bordering to the west are the Front Range Uplift of the Southern Rocky Mountains. The basin itself is characterized by sedimentary rock capped with alluvial deposits from the adjacent mountains.

Rocky Flats is situated in a semiarid region, averaging fifteen inches of annual precipitation. Forty percent of the yearly total occurs in the spring, much of it in the form of snow. Of the balance, half is accounted for by summer thunderstorms, with the remainder occurring in the fall and winter. Average yearly snowfall averages eighty-five inches. Runoff control structures exist to channel surface water from the Plant to monitoring ponds. These structures

Woman Creek supports an aquatic biota typical of small high-prairie streams receiving a minimum of agricultural land runoff and domestic or industrial wastes. Due to the low nutrient content in Woman Creek, the stream supports only a small algal population. The rocky bottom of Woman Creek supports a relatively diverse biota composed of mayflies, caddisflies, and other forms typical of clean water streams. Redside dace minnows are abundant in the stream and in the ponds; a few bluegill are also present.

4.2 REGULATORY COMPLIANCE

Facilities of DOE are required to operate under a policy of full compliance with applicable environmental regulations while conducting their missions. The DOE Albuquerque Operations Office (AL) Environmental Restoration Program is chartered to help fulfill that commitment at installations within the AL complex. The proposed actions are part of this Environmental Restoration Program.

The Program covers the major environmental regulations, such as the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), National Environmental Policy Act (NEPA), Clean Air Act (CAA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), State of Colorado Groundwater Quality Standards, Toxic Substances Control Act (TSCA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), with emphasis on CERCLA and RCRA.

Authority to implement the Environmental Restoration Program is primarily derived from the following DOE and AL orders:

-- Comprehensive Environmental Response, Compensation, and Liability Act Program (DOE 5480.14);

-- Hazardous, Toxic, and Radioactive Mixed Waste Management (DOE 5480.2 and AL 5480.2);

groundwater reaches the valley, it either flows down valley in the alluvium, is consumed by evapotranspiration, or discharges to Woman Creek.

Within the plant boundaries a variety of vegetation thrives. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions, with none being on the endangered species list. It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber-cutting, road-building, and overgrazing for many years. Since the acquisition of the Rocky Flats Plant property, vegetative recovery has occurred as evidenced by the presence of grasses like big bluestem and sideoats grama (two disturbance-sensitive species). On the 881 Hillside Area, the relatively stable soil supports heavy vegetation growth of primarily introduced grasses. No vegetative stresses attributable to hazardous waste contamination have been identified (DOE, 1980).

The animal life inhabiting the Rocky Flats Plant and its buffer zone consists of species associated with western prairie regions. The most common large mammal is the mule deer, with an estimated 100-125 permanent residents. There are a number of small carnivores, such as the coyote, red fox, striped skunk, and long-tailed weasel. A profusion of small herbivore species can be found throughout the plant and buffer zone consisting of species such as the pocket gopher, white-tailed jackrabbit, and the meadow vole (Rockwell, 1988c).

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrows. A variety of ducks, killdeer, and red-winged blackbirds are seen in areas adjacent to ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks, redtailed hawks, ferruginous and American rough-legged hawks, and great horned owls (DOE, 1980).

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers have also been seen. The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE, 1980).

linear with a narrow 100-year floodplain estimated to be approximately 400 feet wide, based upon extrapolation from published Federal Emergency Management Agency Flood Insurance Rate Maps for areas surrounding the plant. A 100-year event would not impact the proposed waste water treatment plant and would not be expected to impact the proposed sumps or the french drain. The South Interceptor Ditch provides additional assurance that the flood crest would not reach the french drain or sumps.

Located between the 881 Hillside Area and Woman Creek, the South Interceptor Ditch roughly parallels the stream and isolates runoff from the south side of the plant until emptying into Pond C-2, where effluents are subsequently discharged into Woman Creek in accordance with the NPDES permit. The ephemeral hydrology of the South Interceptor Ditch is similar to Woman Creek.

4.3.2 Wetlands

Wetlands areas have been identified along both the Woman Creek and South Interceptor Ditch drainage areas. As described in the preceding section, hydrologic factors with respect to Woman Creek (and therefore, the vegetation features associated with them) are not anticipated to be significantly affected as a result of the proposed action. Evenly-spaced drop structures along the South Interceptor Ditch have lowered flow velocities, increased sediment accumulation, and created fairly dense linear stands of wetlands. From a point due south of the 881 Building and extending to the C-2 Pond, approximately 0.15 acres of wetland are contained within this portion of the South Interceptor Ditch. The species are observed to be primarily Typha latifolia or cattails (greater than 95% predominance), Eleocharis macrostachya (spike rush), and Scirpus americanus (bull rush). The wetlands function primarily as flow attenuation with additional minor contributions in wildlife habitat and water quality enhancement.

4.3.3 Endangered Species

The U.S. Fish and Wildlife Service (USFWS) has indicated that the two endangered species of interest in the RFP area are the bald eagle and the

- -- Prevention, Control, and Abatement of Environmental Pollution (Chapter XII of DOE 5480.1 and AL 5480.1);

- -- Environmental Protection, Safety, and Health Protection Information Reporting Requirements (DOE 5484.1 and AL 5484.1);

- -- Implementation of the National Environmental Policy Act (DOE 5440.1C and AL 5440.1B).

4.3 SENSITIVE ENVIRONMENTS AND ENDANGERED SPECIES

The Endangered Species Act of 1973 (Public Law 93-0205), as amended, provides that all federal agencies shall carry out programs for the conservation of listed endangered and threatened species. Federal agencies must ensure that actions authorized, funded, or carried out by them will not jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of historical/archaeological features or critical habitats.

The 881 Hillside Area is not used, nor intended for use, as a public or recreational area, nor for the development of any unique natural resource. No unique ecosystems were found at RFP during extensive biological studies (DOE, 1980).

4.3.1 Floodplains

The 881 Hillside Area lies within the Woman Creek drainage basin area which encompasses approximately 2.63 square miles bordering the southern portion of the Rocky Flats Plant. The stream headwaters just west of the plant boundary and empties into Standley Reservoir to the east. Woman Creek is an intermittent stream, flowing primarily in response to local precipitation events and interaction between the surface and shallow groundwaters. During initial site characterization studies completed in 1986, measurable flows occurred at only four of the eleven gauging stations along the drainage, and all were less than 10 gallons per minute (gpm). The channel configuration is black-footed ferret (USFWS 1988). Prairie dog towns provide the food source and habitat for ferrets. Since there are no prairie dog towns in or near the 881 Hillside Area, the USFWS has determined that ferrets probably do not exist in the investigation area. Bald eagles are occasional visitors to the area, primarily during migration times. Sightings are rare and little suitable habitat occurs on plant site other than some perching locations. No nests occur on plant site. The USFWS has concurred with these findings subsequent to a field visit by the USFWS dated 6/15/88.

4.3.4 Raptors

Other species of high Federal interest that exist in the RFP area include burrowing owls and Swainsons hawks. Cottonwood trees within 1/4 mile of the 881 Hillside Area were investigated to determine if any raptor nests existed in the trees. None were found and the trees will be reinspected in the spring to ensure that activities do not disturb nesting or broods of young. The nearest burrowing owls are approximately 2 miles to the east.

4.3.5 Archaeology

The 881 Hillside Area has been highly disturbed over a number of years. Due to this disturbance and the topographic position of the program area, the State Office of Archaeology and Historic Preservation has determined that this action will not impact cultural resources (DOE, 1988a).

construction activities and shallow trenching in unsaturated soils will not release VOCs and impact air quality.

The risk to workers involved in the interim action, other RFP site employees, and the public from airborne VOCs released from french drain excavation below the water table, well-drilling, and the collection of contaminated groundwater are addressed in Section 5.5, Personnel Exposures - Routine Operations.

Fugitive dust, potentially contaminated dust, and VOCs associated with construction activities will be controlled as specified in the Job Safety Analysis (JSA). The JSA is a process developed from Rockwell policy and administered by the Health, Safety and Environment (HS&E) Group at the RFP to address health and safety concerns encountered by outside contractors. The initial step of the process involves describing each construction task, identifying potential hazards, and determining the steps to control hazards. This review is evaluated and must be approved by the HS&E Group. Upon approval of the JSA, the contractor is briefed and assigned a Rockwell construction engineer. This engineer is responsible for construction and arranges for health and safety training of the contractor. This training requires an understanding of the hazards and controls associated with the construction tasks. Rockwell will then issue a renewable one-week permit, conditional on the workers being briefed and understanding the safety concerns of the construction effort. The construction is continually monitored by the Rockwell HS&E Group for contractor adherence to the JSA.

Exposure to and inadvertent ingestion of airborne radioactivity and low-volatility organic chemicals on fugitive dust is analyzed in Section 5.5. Pollution from engine emissions, fugitive dust generation by vehicles, and particulates from tire wear are analyzed separately in Section 5.8, Transportation Impacts.

The offgases from the UV/hydrogen peroxide treatment system consist of oxygen, carbon dioxide, water vapor, and trace amounts of volatilized organic chemicals (see IM/IRA, Section 4.3.2). The amounts of oxygen, carbon dioxide and water vapor released will not cause measurable changes in the levels of

5.0 ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

The environmental impacts of the proposed interim remedial action for the 881 Hillside Area are evaluated in this chapter. Sections 5.1, 5.2, 5.3 and 5.4 discuss effects to air quality, water quality, terrestrial features, and short- and long-term land productivity, respectively. Human health impacts from routine operations, including construction activities, and accident conditions are evaluated in Sections 5.5 and 5.6. Discussions regarding the commitment of resources, transportation impacts, and cumulative impacts are presented in Sections 5.7 through 5.9.

5.1 AIR QUALITY

There are three potential air quality impacts associated with the proposed action:

1. Volatile organic chemicals (VOCs) released from exposed contaminated liquids during activities such as well-drilling, excavation, or accidents involving spills of collected liquids.

2. Fugitive dusts and fossil fuel consumption-related exhausts resulting from activities such as excavation, construction, maintenance, and monitoring.

3. Water treatment process offgases released to the environment as part of normal operations or accident conditions.

Air quality impacts from construction activities associated with the treatment facility, french drain, source well, footing drain, and associated utilities are small when compared to the normal operational activity at Rocky Flats Plant. During construction, National Ambient Air Quality Standards (NAAQS) for particulates, as well as OSHA standards, will be met. Fugitive dust control measures that are readily available include but are not limited to: watering the source, paving of unpaved roads, and reduction of traffic volume and/or vehicle speed. Sampling has demonstrated that volatile organic chemicals are present in the 881 Hillside Area only at or below the water table. Hence, normal contamination. Should the water be contaminated at levels above the established ARARs, it will be collected for subsequent treatment. Erosion control measures, as specified in the Job Safety Analysis, will prevent any contamination of surface water runoff from potential VOC contamination present in the damp soil excavated from the trenches. However, as noted above, contaminated groundwater is not anticipated to be encountered due to the location of the french drain and current characterization efforts which indicate that contamination is not extensive, as evidenced by the presence of contaminants in only 3 of 23 boreholes (DOE, 1990, Section 2.1.6.2).

While no VOCs have been detected in the soils, much of the excavation for the trenches will occur through soils that are expected to have measurable levels of low-volatility organic chemicals, primarily bis(2-ethylhexyl)phthalate (DEHP). Because DEHP is not transferred from the soil to water in measurable quantities, surface water runoff should not be contaminated from this source. The application of normal erosion control measures to all soils excavated during the remedial action will further ensure that this is the case.

Once installed, all piping and accumulations of contaminated water will be hydrologically upstream of the french drain excavation. Any potential spills will be intercepted by the drain trench.

For the ion exchange columns incorporated into the water treatment for removal of inorganic material, the greatest potential for water quality impacts results from chemicals involved with the periodic regeneration of the resins. Handling of the concentrated ion exchange regeneration chemicals will be governed by the Operational Safety Analysis as will the precautions for handling the waste brine and transportation of the waste brine to the treatment facility. Procedures will be established to assure that waste brine from resin regeneration is segregated from the treated groundwater.

Waste brine generated during resin regeneration operations will be transported by truck to an evaporator at Building 374. This waste is similar to other liquid wastes generated at RFP that are treated at the existing evaporator, as discussed in Section 2.7.3 of the RFP/FEIS (DOE, 1980), and involve no unique hazards or concerns for workers. The volume of waste brine involved these gases in the ambient air. The trace amounts of volatilized organics released from tank vents during normal operation are too low to calculate.

Ion exchange columns incorporated into the water treatment process to remove inorganic material will not contribute to offgases either during normal operation or during resin regeneration operations. Minor leaks of liquid used for resin regeneration and resins exposed to the air during resin bed charging may contribute to odors within the confines of the water treatment building and will be controlled by adequate ventilation. These will not be noticeable from outside the building nor are they a hazard to workers in the building under normal circumstances. Spills of resin regeneration chemicals that might be involved in accident conditions will be administratively controlled by actions specified in the Operational Safety Analysis (OSA).

The OSA addresses health and safety concerns originating from routine site operations. It is similar to the JSA in that health, safety and environmental hazards are identified and evaluated for control. This analysis is also reviewed by and must be approved by the HS&E Group. Training is required prior to operation with oversight and monitoring by the HS&E Group.

5.2 WATER QUALITY

Potential impacts to water quality arising from the proposed action could result from surface runoff entering and flooding drain and utility excavations, soil entrainment (sediment transport) by surface runoff ending in open waters, and potential spills of collected contaminated water into surface waters.

All VOC contamination in the 881 Hillside Area (SWMU 119.1) has been reported in groundwater samples, not in the soil samples. Thus, the excavations performed above the water table (such as the shallow trench for the water collection or return piping) should not involve exposures to VOCs. The trenches for the french drain will be dewatered during excavation if required. It is anticipated that groundwater encountered during construction will not be contaminated, given the location of the drain. Prior to release of any groundwater from dewatering, it will be sampled to confirm the lack of

120 degrees F.; however, after piping and storage, the released water temperature should be similar to ambient conditions. Therefore, thermal impacts are also not anticipated. In summary, it has been determined that there will be no significant impact to wetlands if these parameters are maintained.

5.4 SHORT- AND LONG-TERM LAND PRODUCTIVITY

This area is currently undeveloped and will remain so for the foreseeable future as part of the Rocky Flats Plant. The 881 Hillside Area lies within the security boundaries and is not accessible to the general public.

5.5 PERSONNEL EXPOSURES - ROUTINE OPERATIONS

5.5.1 Assumptions and Methodology

The effects of personnel exposures to hazardous chemicals have been estimated in terms of increased risks to individuals of either developing cancer (carcinogenic risk) or developing some other adverse health effect due to the exposure (noncarcinogenic risk). Analyses were performed separately for those directly involved in remedial actions (workers), other Rocky Flats Plant personnel not directly involved in remedial actions (site employees), and offsite personnel (general public).

The analysis of carcinogenic risk was consistent with the approach used in the risk assessment (RA) included in the Feasibility Study Report (Rockwell, 1988b). Estimates of carcinogenic risks were calculated for each of the organic chemicals identified in Table 2-1, and the individual risks summed for a total carcinogenic risk. The carcinogenic risks are considered to be cumulative for the entire period of exposure, and the calculations yield an estimate for the lifetime increased risk of cancer.

The analysis of noncarcinogenic risks was also consistent with the RA. Noncarcinogenic risks are considered "threshold" events. That is, no effect is will not be a major addition to that already processed by the 374 Building evaporator treatment facility. Thus the collection, transport, and treatment of waste brine will be in accordance with standard plant operating procedures and do not present a significant hazard to on-site or off-site water quality.

The effluent from the water treatment process will be retained in a holding tank and sampled to assure that applicable or relevant and appropriate requirements are met. This water is then surface-discharged into the South Interceptor Ditch which empties into Pond C-2. The water quality of Pond C-2 is again analyzed and, if standards are maintained, released in accordance with the NPDES permit. The NPDES permit allows batch releases, and the additional volume of treated effluent is expected to add one additional release per year.

5.3 TERRESTRIAL IMPACTS

Terrestrial environment features which may be impacted include animal life, plant life, and habitats. The area involved will be less than 5% of the surface area of the 881 Hillside Area. Excavation for the french drain and piping trenches will be locally destructive to the vegetation and ground-dwelling rodents and insects. As none of the rodents, insects, or vegetation are endangered or threatened, they will quickly re-establish their populations in the disturbed areas.

Even though the proposed action will intercept colluvial flow from the 881 Hillside Area which sustains the wetlands habitat, the point of return discharge after treatment will be at the upstream west end of the hillside area. Only minimal impacts to the flow of Woman Creek would be expected since the 881 Hillside Area contributes only a small portion of the overall recharge area to the creek and a portion of the treated water would return to the groundwater system feeding the creek via infiltration from the South Interceptor Ditch. The return flow rate is anticipated to be on the average of approximately 10 gpm; a volume which would be expected to more likely enhance the wetlands features rather than negatively impact them. The UV/peroxide treatment associated with the proposed action will heat the treated water to approximately to a member of the general public were estimated assuming exposure for the entire length of the release (for example, the releases for the operation of the water treatment facility are assumed to continue throughout the entire thirty years of the remedial action). Two exposure categories were considered: one where the member of the public is already an adult when the project starts and the other where the individual is assumed to be a child for the first five years of remedial action and an adult for the remaining 25 years. The numbers in the report represent whichever analysis yielded the highest increased risk of cancer.

The intake of radioactive materials has been assessed by calculating total intake by individuals and converting that to committed effective dose equivalent (CEDE) using the exposure-to-dose conversion factors for inhalation (Table 2.1 of EPA, 1988) and ingestion (Table 2.2 of EPA, 1988) for exposures of workers. Internal Dose Conversion Factors for Calculation of Dose to the Public, Part 2 (DOE, 1988b), was used to assess doses to the public although the conversion factors in these two documents are nearly identical. The calculated values for CEDE are then compared to the DOE limits of 5 Rem per year for workers (DOE, 1988c) and 100 mRem per year for members of the general public (DOE, 1989).

Excavations for the french drain are planned for areas in which the groundwater is not expected to be contaminated with VOCs. Therefore, exposure to airborne VOCs should not pose a risk to workers, site employees, or the general public during installation of the french drain. Nonetheless, risk assessments have been performed as if contaminated groundwater were present to establish an upper bound to the risks that may be involved in the installation of the french drain.

Appendix A contains the details of the calculational methods used for estimation of risk involved in exposure to hazardous chemicals. Appendix F contains the details of the analysis for radiological and toxicological effects of hazardous material suspended in fugitive dust.

observed below a given exposure. Increased risks are based on the average long-term exposure (chronic exposure) and are not cumulative over the exposure period. Exposure levels were averaged over the period of the release or over one year (whichever was shorter) for each of the selected chemicals through each pathway. These levels were evaluated by comparing predicted daily contaminant intakes to the Health Effects Criterion (HEC) (the daily exposure level below which no adverse health effects are expected to occur). HECs used in this report are Reference Doses (RfDs) as developed by the U.S. Environmental Protection Agency or a calculated equivalent if no RfD has been adopted by the EPA.

Personnel exposures to workers, site employees, and members of the general public were analyzed on the basis of a single, hypothetical individual for each exposure category. In the case of workers, this assumed that the same worker was fully involved in each phase of construction, operation, or during any accident. Site employees were assumed to be assigned eight hours a day for the duration of the release to whatever building would receive the greatest average airborne exposure. The analysis of the impact on the general public assumed a single individual would remain at the point of highest exposure accessible to the general public for each pathway, twenty-four hours per day, for the entire duration of the release. Performing the calculations this way provides an upper bound for the increased risks to each of these groups. During the remedial action, it is unlikely that any worker, site employee, or member of the general public would exceed or even approach the risks estimated for their respective group.

In calculations of the estimated increased risks to members of the general public from hazardous chemicals, the impacts on infants and young children were calculated separately from those on adult members of the population. Infants and young children differ from adults in the rate of uptake of the hazardous chemicals as well as in body weight. Both of these factors influence the calculations of increased risk. To assess noncarcinogenic risks, exposures to the chemicals were estimated for both children and adults and compared to the HEC. The results of the analyses for both children and adults are provided in the Appendices. The numbers quoted in the text of this document are those for the group with the greatest increased risk. Carcinogenic risks samples will be taken and analyzed prior to french drain excavation to confirm whether any soils to be removed require handling as a RCRA hazardous waste.

Worker exposure to VOCs in the area around excavations or the stockpiles of excavated soil are expected to be minimal because they are unconfined areas and because the french drain is located downgradient from known VOC contamination. Routine monitoring will be performed and protective control measures specified by the Job Safety Analysis (JSA) will be followed. Should entry into excavated trenches or holes be required during french drain or collection sump construction, sampling will be performed immediately prior to entry and protective measures will be specified as appropriate, based on the level of VOCs detected.

A new source well will be drilled about 15 feet from existing Well 9-74. Because damp soils removed during drilling (approximately 2 ft^3) will be exposed in an unconfined area, any VOC exposure to the air will be small. This soil will be sampled and treated as a RCRA hazardous waste until determined otherwise. Sampling will be performed during well installation and protective measures appropriate for the level of VOCs detected will be specified in the JSA to protect the workers.

Monitoring for VOCs during construction activities will be conducted and any necessary protective action, such as the use of respiratory protective equipment, will be taken as prescribed by Health, Safety and Environment personnel and the Job Safety Analysis specific for this installation.

During routine operation of the water treatment facility, personnel may be exposed to low concentrations of VOCs. Operation and maintenance of the water treatment facility are expected to require an average of two individuals working approximately two hours per day, five days per week. The water treatment process is a closed system, so large volumes of untreated water are not available to produce VOC vapors within the building. The UV/peroxide treatment works by destroying rather than concentrating the hazardous materials. Exposures, therefore, cannot involve sources of contamination greater than the water in the collection tanks. The only normal exposure to vapors would be from sampling or maintenance or from minute system leaks.

5.5.2 Worker Exposure Risks

Workers involved in the installation of collection facilities and those involved in operation of the facilities associated with the remedial action experience increased risks through a number of pathways:

1. Airborne exposure to volatile organic chemicals (VOCs) in the vicinity of excavation, stockpiles of excavated soil, within excavated trenches or holes, or within the water treatment facility.

2. Dermal (skin) exposures to low-volatility organic chemicals or radioactive materials.

3. Inadvertent ingestion of low-volatility organic chemicals or radioactive materials on fugitive dust.

4. Exposure to airborne radioactivity and low-volatility organic chemicals on fugitive dust.

The extent of the increased risks is summarized below. More detailed discussions may be found in the Appendices.

Airborne Exposures to VOCs

The soil samples from the areas closest to the location of the french drain do not yield significant levels of VOCs. Some well water samples from the area hydrologically upstream of the location of the french drain do show low levels of VOCs. With the exception of one sample which yielded 1,1-dichloroethene, no RFP site wells located hydrologically downstream of the french drain have yielded measurable quantities of VOCs in the alluvial groundwater (IM/IRA, Section 2.1.6.1). This chemical has not been detected in subsequent samples from downgradient wells. Methylene chloride and acetone were detected at low levels, but are likely to have been laboratory contaminants, since they were also detected in laboratory blanks. It is thus reasonable to anticipate that workers at the french drain construction site will not be exposed to significant levels of VOCs in water seeping into the excavation. As a precaution, bore minute system leaks. Administrative controls on sampling, hazard control, maintenance, and housekeeping will be specified in the Operational Safety Analysis for operating the facility.

Inadvertent Ingestion

During construction activities, any special clothing requirements or special personnel protective measures required for worker safety will be specified as per the Job Safety Analysis. However, there may be some ingestion of either hazardous chemicals or radioactive material through the inadvertent ingestion of contaminated soil. While risks from volatile chemicals would not be significant through this pathway, the risks from low-volatility chemicals, metals, and radioactive material could be more significant and have been analyzed. Complete details of this analysis may be found in Appendix J, as summarized below:

Bis-(2-ethylhexyl)phthalate is the only low-volatility organic chemical found in the 881 Hillside site soil. The ratio of the estimated uptake from inadvertent ingestion to the appropriate HEC, used as an indicator of increased noncarcinogenic risk, is 9×10^{-6}. The increased carcinogenic risk factor is 6×10^{-12}.

The dose from inadvertently ingested uranium and plutonium was calculated as described in Appendix J. The committed effective dose equivalent is 2×10^{-6} Rem for uranium and 2×10^{-6} Rem for plutonium. These doses may be compared to the DOE annual limit of 5 Rem for occupational workers (DOE, 1988c).

None of the metals analyzed poses a carcinogenic risk from ingestion (nickel poses a carcinogenic risk from inhalation but not oral ingestion). The largest ratio of the CDI to the HEC is 6×10^{-5} for mercury.

Vapor exposures will be controlled by adequate ventilation of the water treatment building.

Dermal Exposures to Low-volatility Organic Chemicals

While soil samples from borings taken in the area where the french drain will be installed did not contain significant levels of VOCs, 3 of 23 borings at the 881 Hillside Area did yield measurable levels of low-volatility organic chemicals which could lead to dermal exposures to workers during excavations for the groundwater collection system, including the french drain. Although appropriate personal protective measures will be specified by the JSA to limit such dermal exposures when sampling indicates the need, estimates have been made of the upper limit of such exposures without protective clothing. The carcinogenic risk associated with these exposures is estimated to be about 1×10^{-9}. The ratio of the estimated Chronic Daily Uptake (CDI) to the Health Effects Criterion (HEC) is 2×10^{-3}. A detailed description of the calculation of these figures may be found in Appendix D.

The installation of a new source well near existing Well 9-74 also involves potential dermal exposures. The level of low-volatility organic chemicals in the soil where the well is to be installed does not exceed those used in the calculation described in the previous paragraph. The noncarcinogenic risks, which are based solely on average exposure level, will not be greater than those in the previous paragraph. Carcinogenic risks are based both on exposure level and period of exposure. Although the exposure levels in well drilling may be the maximum concentration observed, the total carcinogenic risks from the well installation will be less than those reported for french drain installation because the period of exposure will be much shorter and the material will be handled as a RCRA hazardous waste until determined otherwise. Monitoring will be conducted during the well drilling as required by the Job Safety Analysis. Health, Safety, and Environmental representatives will prescribe worker protection actions if necessary.

As with airborne exposure, the only dermal exposure to liquids in the operation of the water treatment facility will be during sampling or maintenance or from

Rem and for plutonium is 3 x 10^{-4} Rem. These totals may be compared to the DOE limit for occupational workers of 5 Rem per year (DOE, 1988c). A complete description of the methods used to perform this analysis may be found in Appendix F.

Low-volatility organic chemicals might also be made airborne with fugitive dust. The risks to the workers from inhalation of this dust have been analyzed and are detailed in Appendix F. The carcinogenic risk factor is 1 x 10^{-8} and for noncarcinogenic risks, the ratio of the chronic daily intake to the appropriate HEC is 1 x 10^{-4}. Analysis of the impacts of inhalation of metals present in the soil indicates that the greatest carcinogenic risk is from nickel at 6 x 10^{-6}. The greatest ratio of the CDI to the appropriate HEC is for mercury which is 4 x 10^{-3}. Details of the analysis may be found in Appendix F.

During operation of the water treatment facility, radioactive materials could accumulate from small leaks or spills of untreated water within the facility. These chemicals are not volatile and are not readily absorbed through the skin. Oral intake presents the only potential concern. Possible accumulations from minor leaks or spills will be controlled to low levels by ordinary good housekeeping practices and as specified in the Operational Safety Analysis.

5.5.3 Site Employee Exposure Risks

The risks to RFP site workers who are not associated directly with the remedial action (site employees) will be due to airborne exposures during construction activities or operation of the water treatment facility. The exposures may be considered in two categories:

1. Fugitive dust carried from the site during construction that may be contaminated with either low-volatility organics or radioactive materials.

2. Organic chemicals released to the air during construction or operation of the facilities.

Exposures Due to Fugitive Dust

Radiation surveys have indicated there are small isolated areas of localized surface contamination in the area of the 881 Hillside. As shown in Table 2-1, no surface samples have yielded plutonium levels greater than 5 pCi/gm, with the average level being 1.63 pCi/gm. No higher levels of Pu are expected to be encountered during excavation because no borehole samples showed measurable quantities of Pu below ground surface. Elevated levels of uranium have been identified in surface soils with measured levels as high as 3,072 pCi/gm. Uranium has been found in deeper soils through borehole analysis in concentrations lower than the surface concentrations. All analyses have been performed using the higher surface soil concentrations to establish an upper bound of risk.

Soil samples have also been analyzed for metals that are classified as hazardous materials. Neither the radioactive materials nor the metals are readily absorbed through the skin, so they do not present a risk to workers from dermal exposure.

During construction of the facilities, the only pathways of concern for workers would be inhalation of fugitive dust generated during the excavation and inadvertent ingestion. The inadvertent ingestion pathway was discussed in a previous subsection of this report. Dust control measures would be specified in the JSA to limit inhalation exposures. These measures include the premoistening of the excavation area with a sprinkler system for three days prior to start-up and the continued moistening of the site throughout the excavation. Ambient air high volume air samplers will be used to measure radiation and wind velocity. Operations will be suspended by requirements in the OSA if wind velocity exceeds 15 mph or alpha radiation exceeds 0.03 pCi/m^3.

Nonetheless, an analysis has been made of the potential inhalation of dust contaminated with plutonium or uranium, and the committed effective dose equivalent (CEDE) from such an intake. If the amount of dust stirred up were to remain less than 10 mg/m^3 (the OSHA regulatory limit on nuisance dust in the work environment), the CEDE calculated for uranium is 5 x 10^{-2}

Table 5-1

RISKS TO THE SITE EMPLOYEES FROM AIRBORNE ORGANIC CHEMICALS

Exposure Source	Total Carcinogenic Risk (Risk Factor)[1]	Non-carcinogenic Risk (CDI:HEC)[1]
Excavation for French Drain		
-- Fugitive dusts	<1 E-8[2]	<1 E-4
-- VOCs	1 E-11	3 E-5
Water treatment facility building ventilation exhaust	<2 E-9	<4 E-6
Influent collection tank vent releases	2 E-9	4 E-6
Effluent surge tank vent releases	1 E-11	2 E-7
Total for all sources	1 E-8	1 E-4

[1]See Appendix B, Special Terms Used in This Report.

[2]1 E-8 = 1×10^{-8} = 0.00000001

Exposures Due to Fugitive Dust

All site employees not involved in the remedial action will be more distant from the site than those involved in the construction activities. Accordingly, the risks to site employees will be lower than those of the workers which were discussed in Section 5.5.2 of this chapter. Because the exposures associated with airborne dust contaminated with uranium, plutonium, and metals were calculated to be well below regulatory limits for workers, they were not calculated for site employees. The risk impact of low-volatility organics is examined with other chemical exposures in the following paragraphs.

Airborne Exposures to Organic Chemicals

During construction and installation activities for the proposed action, the potential exists for site employee exposure to airborne VOCs released during excavation for the french drain. However, as previously noted, it is expected that contaminated water will not be encountered during this activity due to the location of the drain and JSA precautions, including sampling prior to excavation. An upper estimate of risks to site employees from this potential source of VOC exposure has been calculated and is summarized in Table 5-1. A detailed description of the basis for the numbers in Table 5-1 may be found in Appendix E.

During excavation for the french drain trench, if there is a need for dewatering, there could be VOCs released from water withdrawn from the excavation. Because the liquids from dewatering do not include the source well, potential concentration levels in the dewatering fluids are expected to be significantly less than those used for analysis of either routine operation or accident conditions and need not be analyzed further.

Dust control procedures, as previously discussed, will be used during construction to limit exposures from fugitive dusts. However, an estimate of the upper bound of the risks from exposure to dusts contaminated with low-volatility organic chemicals has been included in Appendix F. The results of these calculations have been included in Table 5-1.

3. Dermal exposure to low-volatility organic chemicals if the area is released from administrative control.

The extent of the increased risks is summarized below. More detailed discussions may be found in the Appendices.

Airborne Exposures

During construction and installation activities for the proposed action, the general public could be exposed to the same sources of airborne VOCs as were discussed in the section on site employees. The risks to the general public from this source of VOC exposure are summarized in Table 5-2. A detailed description of the basis for the numbers in Table 5-2 may be found in Appendix E.

The same sources of VOCs that could impact site employees during water treatment facility operation could also expose members of the general public. The associated risk estimates are summarized in Table 5-2.

The general public may also be exposed to low-volatility organic chemicals through fugitive dust generated during excavation activities. An estimate of the upper bound of the risks from these materials has been included in Appendix F. The results of these calculations have been included in Table 5-2.

The only source of radioactivity to members of the public would be inhalation of fugitive dust generated during the excavation. Dust control measures would limit these exposures as well. Nonetheless, analyses have been performed of the airborne levels at the nearest off-site location, the potential uptake of radionuclides by a member of the public, and the resulting committed effective dose equivalent (CEDE). If the work were to continuously create an airborne dust loading of 10 mg/m^3 (the OSHA limit for nuisance dusts), the resulting average dust levels offsite would lead to doses to a member of the public of 5×10^{-3} mRem from uranium and 8×10^{-5} mRem from plutonium. These doses may be compared to the annual limit on CEDE of 100 mRem, as established by the DOE (DOE, 1989).

Three sources that could impact site employees have been identified for VOCs that might be released during water treatment. Each source is individually described in the following paragraphs. All associated risk estimates are summarized in Table 5-1.

1. The influent collection tanks are to be vented to the atmosphere which may lead to the release of VOC vapors prior to water treatment. The methods used to estimate the risks are described in Appendix A and the calculation of the source concentration used is described in Appendix C.

2. Trace amounts of VOCs may be present in the treatment building ventilation exhaust. In routine operations, this might include VOCs from leaks in the treatment system or VOCs released during sampling or maintenance of the system. Such releases are much less than the offgassing from the influent collection tank vents.

3. Small amounts of VOCs may remain in the treated effluent. Some vapors may escape through the effluent surge tank vent. The estimates of risks are included in Table 5-1 and are detailed in Appendix E.

5.5.4 Risks From Exposure To Members of the Public[1]

There are three possible pathways for exposures to the general public:

1. Hazardous chemicals and radioactive particulates released to the air during construction activities or the operation of the water treatment facility.

2. Hazardous chemicals remaining in the water released after processing.

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[1] Throughout this report, the term "general public" has a special and very restricted meaning. In order to estimate the maximum exposure or risk to persons outside of the RFP site, all estimates are based on the exposure to a person at the site boundary location having the highest airborne concentrations and remaining there for 24 hours each day, 365 days each year, for the duration of the operation or the remedial action (see also Appendix B).

Fugitive dusts may also contain metals found in the soil. Appendix F contains the details of the analysis of associated risks to the public. The greatest carcinogenic risk from metals, 8×10^{-10}, comes from nickel. The highest ratio of CDI to HEC for a metal is 5×10^{-6} (mercury).

Hazardous Chemicals in Processed Water

The second pathway involves hazardous chemicals that remain in the water released from the treatment facility and might eventually enter a body of water used for drinking water. To place an upper bound on this pathway, it was assumed that the water released from the treatment facility contains both volatile organic and inorganic chemicals at the minimum detectable limit when released. It was further assumed that no VOCs offgas either in the effluent surge tank or before reaching the collection pond C-2. This is conservative due to the fact that sampling results clearly demonstrate that the VOCs in the 881 Building footing drain water are lost to the atmosphere rapidly enough to be undetectable in the interceptor ditch. It was further assumed that the VOCs collect in Pond C-2 for two weeks without losses. Inorganic materials were assumed to collect for six months without losses either to the bottom sediments or in water released from the pond. The water treatment facility was assumed to be operated at its design capacity five days per week, releasing all the treated water to Pond C-2 and that C-2 remains at the normal operating level of 3,087,500 gallons at all times. Under these conditions, the carcinogenic risk would be 6×10^{-6} and the noncarcinogenic risk ratio is 0.2.

Dermal Exposures to Low-volatility Organic Chemicals

The proposed action treats the groundwater, not the soil in the SWMUs. When the groundwater VOC levels have decreased enough to permit termination of the treatment, low-volatility organic chemicals may still be found in some of the soil. The risk assessment (Rockwell, 1988b) demonstrates, however, that even after an assumed loss of institutional control over the area, none of the soil pathways produce either carcinogenic or non-carcinogenic health effects great enough to be significant. The total lifetime carcinogenic risk for all soil-bound pathways is 4×10^{-7} for the maximally exposed individual

Table 5-2

RISKS TO THE GENERAL PUBLIC[1] FROM AIRBORNE HAZARDOUS CHEMICALS

Exposure Source	Total Carcinogenic Risk (Risk Factor)[2]	Non-carcinogenic Risk (CDI:HEC)[2]
Excavation for French Drain		
-- Fugitive dusts	2 E-12[3]	1 E-7
-- VOCs	2 E-12	1 E-6
Water treatment facility building ventilation exhaust	<1 E-11	<1 E-8
Influent collection tank vent releases	1 E-11	1 E-8
Effluent surge tank vent releases	5 E-14	4 E-10
Total for all sources	2 E-11	1 E-6

1 In order to estimate the maximum exposure or risk to the general public, all estimates are based on the exposure to a person at the site boundary location having the highest airborne concentrations and remaining there 24 hours per day, 365 days per year.

2 See Appendix B, *Carcinogenic Risk*.

3 2 E-12 = 2×10^{-12} = 0.000000000002.

5.6.2 Accident Scenarios

Any accidents which may occur during the construction phase of the proposed action are those typical of small excavation or construction activities. While such an accident might lead to personnel contamination from contaminated groundwater or soils, none of the hazardous materials have been identified in concentrations immediately injurious to health. The Job Safety Analysis (JSA) will identify preventive/corrective actions and the parties responsible for each basic job. Workers are required to be familiar with the JSA, and a copy of it will be available at the work site. Potential impacts to either workers, site employees, or members of the public from all reasonably foreseeable accidents that may occur during construction are bounded by those accidents described in the following paragraphs.

During the operational phase, accidents that could impact workers or members of the public would involve fires or major spills of contaminated material. Because the hazardous material is treated in water, fires could be an industrial hazard but would not produce airborne releases.

Spills of untreated water within the treatment building would create the potential for short-duration airborne VOCs. Uptake of contaminants by workers involved in the cleanup would be controlled by following safety precautions specified in the Operational Safety Analysis. There might be airborne releases through ventilation systems that could lead to exposures of other RFP employees (site employees) or the general public, but these would be less than releases from a spill outside the building as described in the following paragraph.

As described in Appendix G, the most severe credible accident with potential for the exposure of either site employees or the public would be airborne VOCs released with the rupture of one of the 15,000-gallon influent collection tanks with subsequent release of the VOCs to the air. Spread of the water would be confined by the dike surrounding the tank. Under these circumstances, the highest carcinogenic risk factor to site employees would be 3×10^{-8}. The highest carcinogenic risk to the general public would be 4×10^{-10}. If it is assumed that all the VOCs in the water are released to the air within in the worst-case scenario defined in the risk assessment. None of the Health Effect Criteria are exceeded for any of the soil pathways in the same scenario, thus keeping noncarcinogenic risks below acceptable limits.

5.6 PERSONNEL EXPOSURES - ACCIDENTS

5.6.1 Assumptions and Methodology

A "bounding case" accident analysis approach was used to assess accidental exposure risks for this interim action. Carcinogenic and noncarcinogenic risks to site employees and the general public were calculated. Methods of calculation are similar to those used for exposure risks associated with routine operations, with the exception that it was assumed that all dissolved VOCs are released to the air over the first twenty-four hours. Also, the uptake by the most critical member of the public extends over this same period of time.

The dispersion factors used in the analysis of accidents differ from those used in the analysis of routine operations or installation. For long-term exposures such as construction or operations, the value of X/Q includes the frequency of winds in the direction of interest. For accident situations, the wind is assumed to be blowing in the most critical direction, i.e., that direction in which exposures would be highest. Hence, for the analysis of on-site employee impacts, the wind is assumed to be blowing towards the closest occupied building. For exposure of the public, the wind is assumed to be blowing towards the closest site boundary.

The factors used for dispersion during an accident event are also calculated differently to account for short-term variations in atmospheric conditions rather than the long-term averages for routine operations. The methods used to calculate the dispersion factors for use in the accident analysis may be found in Appendix I.

5.8 TRANSPORTATION IMPACTS

Human health impacts normally incident to transportation include latent effects associated with vehicle pollution, in addition to traumatic injuries and fatalities resulting from accidents.

Normal transportation is associated with incremental pollution from engine emissions, fugitive dust generation in the vehicle's wake, and particulates from tire wear. The table below presents estimates of risk (Rao, 1982) resulting from truck and rail transportation. Uncertainties are associated with pollution

Source	Transportation Mode	Health Effects per Kilometer		
		LCFs*	Injuries	Fatalities
Pollutants	Truck	1.0 E-7 (urban only)		
	Rail	1.3 E-7 (urban only)		
Accidents	Truck		5.1 E-7	3.0 E-8
	Rail		4.6 E-7	3.4 E-8

* LCFs represent latent cancer fatalities resulting from incremental vehicle pollution, and would occur after a latency period following initial exposure.

emission rates and atmospheric dispersion behavior. To compensate for these uncertainties, the analysis utilized conservative estimates for determining pollution health effects. The tabulated accident impacts are average values over all population zones (urban, suburban, rural) and are derived from Department of Transportation nationwide statistics.

The proposed action does not involve either routine on-site or off-site shipment of contaminated materials and consequently will not have any potential impacts associated with the transportation of contaminants. Excavated soils are to be

24 hours, the ratio of the daily uptake for a member of the public and the appropriate HEC is less than 5×10^{-3}.

If all the VOCs are assumed to be released within one eight-hour shift and that the wind is blowing continuously toward the nearest building to the 881 Hillside Area (the 881 Building), the ratio of the daily uptake to the HEC would be 0.7. It would be expected, however, under the circumstances described, that the building or buildings downwind from the scene of the accident would be evacuated if air sampling indicated a potential problem, thus lowering the noncarcinogenic risk for the site employees potentially involved.

5.7 COMMITMENT OF RESOURCES

The scope of the proposed action is small and the resources (material/manpower) for construction and operation will likewise be small. No significant commitments of valuable resources are involved.

With the exception of the land area, all of the construction and operation-related material will be irrevocably and irretrievably committed to the implementation of the remedial action. Most of these resources are normally consumed at the plant at a rate which makes the requirements of the remedial action insignificant. It is expected that ion exchange resins from the water treatment process to remove organic chemicals and the regeneration chemicals will be similar to resins and chemicals already in use on site and discussed in the RFP/FEIS (DOE, 1980). It is also expected that the resins and regeneration chemicals will be readily available from off-site sources and that the volume of both resins and regeneration chemicals used will not be the cause of shortages in the business community. The anticipated usage of hydrogen peroxide and ultraviolet lamps will be well within local supplies.

Section 17 of the On-site Transportation Manual. The very small number of shipments involved will result in an insignificant impact to human health.

Use of ion exchange columns in the water treatment process for inorganic chemical removal will involve periodic delivery of regeneration chemicals for the ion exchange resins and, possibly, infrequent shipments of replacement resins. It is expected that the number of shipments required will be small and will result in an insignificant impact to human health.

5.9 CUMULATIVE IMPACTS

Routine water processing arising from the treatment of VOCs would not create significant increases in solid wastes at RFP. All gaseous and liquid releases of contaminants will be essentially undetectable off-site. None of the materials that might be released are expected to be concentrated by any natural processes. Therefore, releases from water treatment will not add to any other plant releases to have a cumulative effect.

The reprocessing of ion exchange resin regeneration waste brine will cause an increased load on the evaporator at Building 374. Additional evaporator solids will be generated. Neither effect, however, is great compared to the current loading and output of the evaporator, nor are the types of liquids input or solids output expected to be noticeably modified. When the resins need to be replaced or removed at the completion of processing, they will add a very small amount to the current solid waste volumes. None of the chemicals to be collected on the ion exchange resins are defined as hazardous materials in shipping regulations. Any uranium accumulation on the resins is not expected to exceed exempt quantities by weight, so shipment of exhausted resins, if that is required, is not expected to cause any special concerns or require special controls.

Construction activities will result in increased vehicular traffic, increased engine emissions, and additional workers. The 1980 Rocky Flats Plant Environmental Impact Statement (DOE, 1980) notes a yearly loading of 300 additional construction personnel on average. The number of construction personnel distributed over the immediate area of the remedial action site and will not require shipment to another location. If, during construction activities, areas of localized radioactive contamination are identified and excavated as discussed in Section 5.5.2, the associated impacts due to transportation of the excavated material would be essentially the same as described in Appendix H of this report. It is not anticipated that more than a single shipment would be involved so the attendant risks would not present a significant impact to the public.

The proposed action will involve transportation activities during the construction phase as well as during subsequent operation. All shipments are anticipated to be by truck and originate within the Denver metropolitan area, within a 50-mile radius of the plant site. Construction materials to be brought on-site include process treatment components, drain rock (7,334 yd^3), synthetic liners for the french drain (5,500 yd^3), concrete sumps, pumps, piping, and associated equipment. The delivery of these materials will require approximately 520 truckloads over a two-month period. The resulting transportation impacts will be small, as seen from the tabulated health effect estimates (Rao, 1982). To place transportation impacts to the general public in perspective, based on the health effects tabulated above, approximately 60,000 round-trip truck shipments (with a one-way distance of 50 miles) would be required to cause one additional latent cancer fatality. An average of 210,000 truck shipments would be required to result in one additional traumatic fatality.

The increase in site traffic will be noticeable but will be of short duration. External to the plant boundary, the increase in traffic level will not be noticeable.

Normal operation will require deliveries of hydrogen peroxide of approximately 400 gallons per month. Deliveries will likely be handled by one of the existing plant chemical suppliers. Transport and handling of hydrogen peroxide (classified as an oxidizer in Department of Transportation (DOT) regulations) will be in accordance with the On-site Transportation Manual. Emergency response procedures to accidental spills or container failures are described in required for the proposed action will be a small portion of this assumed yearly construction loading.

Excavation for the french drain may expose small amounts of VOC-contaminated soils, as discussed in Section 5.5. The airing of such soils will create temporary low-level releases of contaminant vapors to the atmosphere. Monitoring will be performed in accordance with the Job Safety Analysis. It is unlikely that any measurable concentrations of vapor will be found since the exposed material will be in an unconfined area. The amount of vapor thus released will be insignificant.

On-site traffic may be temporarily disrupted by the trenching for underground piping from collection points to the water treatment facility. These disruptions would be short (one day) and occur in low-traffic areas.

Immobilization of volatile organic and inorganic contaminants, using a polymer grout (460 injection wells), would have slightly lower workforce exposures and somewhat lower short-term environmental impacts than the proposed action. Construction impacts, while destructive to the site's immediate flora and fauna, will be short term. Unlike the proposed action, this alternative would neither remove nor destroy contaminants. A major disadvantage is the uncertainty regarding its long-term containment effectiveness due to soil characteristics and the attendant potential for future exposure to the public. The lack of contaminant removal or neutralization could result in a lengthening of the period required for institutional control.

The Comprehensive Well Array and Treatment alternative would both remove and destroy volatile organic and inorganic contaminants. This would result in short-term environmental impacts being somewhat less than the proposed action. Installation risks would be somewhat decreased, but those risks are not great. Exposure to workers during operation of the system could increase slightly as there would be an increase in the number of pumps that might require maintenance. The overall risks to personnel, both workers and general public, using a series of dewatering wells would be nearly the same as using a french drain. However, the well array is not expected to be as effective as a french drain, which is incorporated in the proposed action, in collecting contaminants and preventing downgradient migration.

The French Drain and Soil Flushing alternative is similar to the proposed action but incorporates a leach field for reinjection of a portion of the treatment plant effluent to accelerate removal of contaminated groundwater. The construction of the leach field, while involving excavation of approximately the same volume of soil as the installation of the french drain, would be expected to involve less risk to both the workers and the general public. The excavation is expected to be relatively shallow and should not involve soils below the water table; so volatile organic chemicals, which are primarily confined to the groundwater, would not be of concern for either workers or non-workers. The alternative involves a trade-off between a reduced remedial action period and greater environmental impacts associated with construction of the leach field.

6.0 ENVIRONMENTAL EFFECTS OF ALTERNATIVES

6.1 ALTERNATIVE COMPARISONS WITH PROPOSED ACTION

The following discussion provides a summary of the comparison of impacts from all remedial action alternatives identified in the 881 Hillside Feasibility Report Study and IM/IRA Plan.

The No Action alternative would not involve any short-term impacts to the environment or workforce/general public and would eliminate the need for any off-site transportation activities. However, it would not contain, remove, or destroy volatile organic contaminants which may pose a long-term release risk to the general public and may require alternative actions in the future.

Short-term environmental impacts from the Total Encapsulation and Source Well and Footing Drain Collection with Treatment alternatives would be somewhat less than the proposed action, since they would be focused on a smaller area. Exposure of workers to volatile organics during construction activities for both alternatives would be less than the proposed action, since contaminated soil would likely not need to be disturbed. This will tend to be offset by the fact that contaminant concentrations at the influent from the source well or dewatering operations will be much higher than those from the french drain. The net result is that no differences in health effects would be expected. Following construction activities for both alternatives, exposure of workers and the public to volatile organics would be comparable to the proposed action. While the Total Encapsulation alternative would involve limited removal of volatile organic contaminants as a secondary benefit associated with dewatering, this would not be as thorough as the proposed action and would likely extend the period of time required for institutional control. The Source Well and Footing Drain Collection with Treatment alternative would have a remedial action period comparable to the proposed action, but would involve limited volatile organic and inorganic contaminant removal and destruction. Both alternatives have the disadvantage of permitting low concentrations of volatile organics to continue to migrate downgradient of the remediation areas towards the plant boundary.

The No Action alternative would require that the current semi-annual site monitoring be continued. Since the monitoring is a part of the existing plant environmental monitoring program, the impact on plant operations and the surrounding community would be effectively zero. However, because off-site migration may occur in the future and because federal and state regulations require remedial action, the No Action alternative is unacceptable.

Personnel Exposure

The No Action alternative will have minimal impact on current workers at the site or at adjacent sites. Workers would be required only for semi-annual sampling, which would present no additional impacts. The source of hazardous material would be neither removed nor controlled. Therefore, the possibility of releasing contaminated water off-site would increase over time. The site would then be a source of public exposure in the long term.

The Risk Assessment (Rockwell, 1988b) quantifies the risks to members of the public for each of two scenarios within the No Action alternative: Scenario A assumes residential construction on the plant site (loss of institutional control); Scenario B assumes residential construction at the plant boundary (contaminated water pathway). The carcinogenic potency factors for this alternative are so high that conventional linear risk modeling is inappropriate. As shown in Table 6-1, carcinogenic risks associated with the Maximally Exposed Individual in Scenario A, for one chemical (1,1-dichloroethene), is 0.9. In this case, the additive risk of other chemicals and exposure pathways could mathematically exceed 1.0.

Table 6-2 summarizes the pathways involving exposures which would exceed Acceptable Chronic Intakes, as identified in the Risk Assessment. In addition to adults, the impacts on infants and young children are calculated separately from

The French Drain and Partial Excavation alternative is another variation of the proposed action and involves excavation of approximately 3,000 cubic yards of soil from a circular area around the SWMU 119.1 source well. Excavation of one of the primary contamination sources would reduce the remedial action period, but would require approximately 40% additional excavation and associated environmental impacts and would result in greater exposure of the workers and general public to volatile organics during construction. This alternative would also require approximately 200 truck shipments of contaminated material to an approved off-site location. While the associated risks to the public would be small, the truck shipments would be viewed locally as a more controversial issue than the proposed action.

The four alternatives that were eliminated during the CERCLA screening process (Immobilization, Comprehensive Well Array and Treatment, French Drain and Soil Flushing, and French Drain and Partial Excavation) exhibit a potential for greater environmental impact and/or a limited capacity to remediate groundwater contamination when compared to the proposed action. On this basis, there is no further analysis performed on these alternatives. The environmental effects of the three alternatives retained by the CERCLA screening process, however, are evaluated in detail in the following section.

6.2 ENVIRONMENTAL EFFECTS OF RETAINED ALTERNATIVES

The following is a detailed review, concerning impacts regarding environmental quality, personnel exposure and transportation issues, for each of the three retained alternatives.

6.2.1 Environmental Effects of No Action

Environmental Quality

There are no current indications of contaminant impacts on the plant and animal life of the 881 Hillside Area (Rockwell, 1988c). Local groundwater exhibits high contamination which is slowly migrating. Although no offsite contamination has been found, it is conservatively estimated that these contaminants could reach the site boundary in approximately 20 years (DOE, 1990).

Table 6-2

EXPOSURE PATHWAYS IN WHICH ESTIMATED DAILY INTAKE EXCEEDS ACCEPTABLE CHRONIC INTAKE NO ACTION ALTERNATIVE[1]

Indicator Chemical	Scenario A				Scenario B			
	AA	AC	MA	MC	AA	AC	MA	MC
Carbon Tetrachloride	X	X	X	X	X	X	X	X
1,2-Dichloroethane	X	X	X	X			X	X
1,1-Dichloroethene	X	X	X	X		X	X	X
t-1,2-Dichloroethene		X	X	X				X
Tetrachloroethene	X	X	X	X				X
Trichloroethene	X	X	X	X		X	X	X
Nickel			X	X				
Selenium	X	X	X	X				X
Strontium	X	X	X	X	X	X	X	X
Uranium		X	X	X				

AA = Average Adult Exposure
AC = Average Child Exposure
MA = Maximally Exposed Adult
MC = Maximally Exposed Child

[1] Excerpted from (Rockwell, 1988b), Table 5-26.

Table 6-1

CARCINOGENIC RISKS ASSOCIATED WITH THE NO ACTION ALTERNATIVE[1]

	Estimated Total Lifetime Carcinogenic Risk	
	Average Exposed Individual	Maximally Exposed Individual
Scenario A Residential Construction On Site	2 E-1[2]	>9 E-1[3]
Scenario B Residential Construction At Site Boundary	4 E-3	6 E-2

1 Excerpted from (Rockwell, 1988b), Tables 5-10 through 5-13.

2 2 E-1 = 2×10^{-1} = 0.2

3 Based on linear modeling of drinking water ingestion for 1,1-dichloroethene.

however, no migration has currently been detected in Woman Creek. The lack of contaminant removal or neutralization could result in a lengthening of the period required for institutional control.

Personnel Exposure

Because the installation of bentonite walls would be performed outside of those areas with the potential of high contamination, installation of the walls will not involve increased risks for either workers or the general public. Furthermore, it is not expected that excavation for the cap would be deep enough to involve highly contaminated soil.

The initial and repeated dewatering operations within the contaminated area would provide the potential for worker contamination. Contamination levels in the dewatering liquids would most likely be considerably higher than average groundwater levels in the 881 Hillside Area and would pose higher exposure risks to workers. Because encapsulation isolates but does not treat or remove the contaminant source, future exposures may become possible with the loss of institutional control. Activities that compromise the integrity of the cap or walls may result in exposures, either by leading to direct contact (as with excavating, etc.) or the re-introduction of water, permitting a liquid pathway for exposure.

Transportation

The Total Encapsulation alternative would have negligible transportation impacts, though it would involve on-site transfer of contaminated groundwater. Appendix H estimates that approximately 460 truck shipments would be required to support construction of the slurry wall and RCRA cap and that this would occur over approximately a three-month period. Transfer of collected, contaminated groundwater would likely be required during the initial dewatering phase, with subsequent on-site shipments occurring on an annual basis. The location, limited number of shipments, and procedural controls implemented would effectively eliminate any public health effects associated with contaminated groundwater handling and transportation and minimize related worker impacts.

those on adult members of the population. It is clear from these two tables that both types of risks are above acceptable limits.

Transportation

The No Action alternative would incorporate both groundwater and surface water monitoring and utilize existing wells. No remedial activities would be performed. Consequently, there would be no on-site or off-site transportation activities associated with this alternative or related impacts to workers or the general public.

6.2.2 Environmental Effects of Total Encapsulation

Environmental Quality

The bentonite slurry wall and RCRA cap will require approximately 6,800 cubic yards of bulk construction materials (soils and drain rock). Construction impacts, while destructive to the site's immediate flora and fauna, will be short term. As with the grouting, the activity will be focused on a small area.

Both labor and material requirements will be supplied by local sources. Project requirements for labor and materials are very small. Soils used in cap construction will be brought in from off-site. Until the vegetative cover is replaced, there will be a brief period during which there may be pollution of surface waters due to soil erosion. The drain rock and the short construction period will limit the impact substantially. There will be a change in land contour amounting to the addition of four feet of cover over the entirety of the two SWMUs.

The Total Encapsulation alternative will remove a great deal of the contaminated groundwater in the process of initial and subsequent annual dewatering operations. While the purpose of the dewatering is to assist contaminant containment, a beneficial side effect will be to provide limited decontamination of the area that has been encapsulated. This alternative would not incorporate a treatment process which destroys collected contaminants. Contaminants which have already migrated out of the SWMU boundaries will not be contained;

source well, the concentration of the collected influent will be higher. This will increase the effects of any accidents (system leakage or influent tank vent releases) and the attendant, potential exposure of off-site personnel.

The potential for future releases via the groundwater would remain, although the eventual release levels would be lower than in a No Action scenario. Because the draw-down of the water table by a single well would not extend adequately throughout the region of contaminated groundwater, there would remain the potential for exposures similar to but less than those described in the No Action alternative. The amount of contaminated groundwater would be decreased by this alternative, so the risks would be lowered but not eliminated.

Transportation

This alternative would involve periodic delivery of hydrogen peroxide to the plant site to support treatment facility operations. As determined in Appendix H, approximately 275 truck shipments would be required during construction. Associated transportation risks would be very small. Shipment of contaminated material would not be required.

6.3 CONCLUSIONS

From the foregoing discussion in Sections 6.1 and 6.2, the proposed action is judged to be more favorable than the alternatives regarding potential environmental impacts and benefits and in its comprehensiveness to contain, remove, and destroy contaminants.

Potential impacts associated with the proposed action and all identified alternatives are compared in Table 6-3. This comparison is generally qualitative in nature, with selected alternative activities quantified where more detailed information is available. Development of the transportation impacts associated with each alternative is summarized in Appendix H.

6.2.3 Environmental Effects of Source Well and Footing Drain Collection with Treatment

Environmental Quality

The near-term environmental impacts of this alternative are small, as the only new construction necessary is a collection sump at the SWMU 107 drain outfall, the effluent reinjection trench, and associated piping trenches. The conversion of an existing structure to a treatment facility is perhaps the largest effort, but that will occur in a previously developed area easily accessed and already heavily traveled.

The material and manpower requirements will be inconsequential with respect to local market resources.

The piping trenches, footing drain collector, and leach field will comprise the total excavation requirements of this project. There will be little or no excess soils or uncovered soil areas to produce erosion, and there will be no noticeable change in land contour.

This alternative has little effect on the migration potential of the hazardous materials. It does remove the major contaminant media and destroys the contained contaminants. However, it will only address identified pockets and not the contamination problem as a whole, allowing downgradient contaminants to continue migrating. This alternative relies on the assumption that the lower concentrations of remaining contaminants will be diluted to very low levels by the time off-site migration occurs.

Personnel Exposure

By not including a french drain in this alternative, the exposure from operation and/or accident scenarios are affected in two ways. A portion of the contaminant plume hydrologically downstream will not be collected or treated, reducing the total contamination processed and thus reducing, to an indeterminant degree, the exposure involved for both workers and the general public. Without the flow from the french drain, which will be of a much lower concentration than the

Table 6-3 (Continued)
SUMMARY COMPARISON OF POTENTIAL IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

Impact Category	Proposed Action	Alternatives						
		No Action	Total Encapsulation	Source Well and Footing Drain	Comprehensive Well Array	French Drain & Soil Flushing	Immobilization	French Drain & Partial Excavation
Exposure of Workers								
Construction	Negligible dermal exposure to contaminated soils in trench; trace VOC vapor exposure near excavations.	none	none	none	Similar but slightly higher risks than for proposed action.	Exposure risk similar to proposed action; add'l excavation adds to ordinary const. accident risks.	Negligible dermal exposure to soils and liquids from drilling operations.	Substantially higher dermal & inhalation exposures over proposed action.
Routine	Trace VOC vapor exposure while in building, 2 hr/day	none	Routine dewatering could result in negligible dermal and inhalation exposures to VOCs.	Similar to risks for proposed action.	Similar but slightly higher risks than for proposed action.	Similar to risks for proposed action.	none	Similar to lower risks than proposed action.
Accident	Contaminated water and hydrogen peroxide dermal exposure w/ negligible result. Trace VOC vapor inhalation w/ negligible impact.	none	Negligible risk of dermal or inhalation exposures to VOCs through transport spills of contaminated waters.	Similar but slightly lower risks than proposed action.	Similar to risks for proposed action.	Similar to risks for proposed action.	none	Similar to lower risks than proposed action.
Off-site Transportation								
Construction (truckloads)	520	0	463	275	280	802	71	925
Operation (truckloads/yr)	2-3	none	none	2-3	2-3	2-4	none	2-3
Contaminated Materials (truckloads)	none	none	none	none	none	none	none	200
Cumulative Impacts to RFP Site	small	none*	small	small	small	Small but greater than proposed action.	small	Small but greater than proposed action.

* No direct impacts but results of inaction may lead to eventual conditions having a great impact on the site.

Table 6-3
SUMMARY COMPARISON OF POTENTIAL IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

Impact Category	Proposed Action	Alternatives						
		No Action	Total Encapsulation	Source Well and Footing Drain	Comprehensive Well Array	French Drain & Soil Flushing	Immobilization	French Drain & Partial Excavation
Environmental Impacts								
Excavation	7440 yd^3	none	600 yd^3	none	none	11,600 yd^3	none	10,300 yd^3
Well drilling	1	none	2	1	166	1	460	1
Topographical deformation (permanent)	none	none	3-4' cap	none	none	hillside terrace	<1"	none
Endangered Species Impacts	none	none	none	none	none	none	none	none
Wetlands Impacts	none	none	none	none	none	none	none	none
Cultural Impacts								
Resource Consumption	small	negligible	small	small	small	Small but greater than proposed action.	Less than proposed action.	Small but greater than proposed action.
Archaeological Impacts	none	none	none	none	none	none	none	none
Long Term Considerations								
Remedial Action Period (Institutional Control)	~30 yrs	>30 yrs	>30 yrs	~30 yrs	~30 yrs	<30 yrs	0	<30 yrs
VOC Contaminant Removal	yes	no	limited	limited	yes	yes	no	yes
VOC Contaminant Destruction	yes	no	no	limited	yes	yes	no	limited
Inorganic Contaminant Removal	yes	no	limited	limited	yes	yes	no	yes
Exposure of General Public								
Construction	Negligible truck shipments	none	Negligible truck shipments	Negligible truck shipments	Negligible truck shipments	Negligible truck shipments	Negligible truck shipments	Negligible truck shipments
Routine	none	Future release risk	Future release risk	none	none	none	Future release risk	none
Accident	none	none	none	none	none	none	none	none

Table E-5

RISKS TO SITE EMPLOYEES FROM VOCs RELEASED FROM THE EFFLUENT SURGE TANK VENT

Volatile Organic Chemical	VOC Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Risk[1]	
				Carcinogenic	Noncarcinogenic
Carbon Tetrachloride	4.50 E-7[2]	9.32 E-7	1.81 E-10	1.80 E-13	8.48 E-8
1,2-Dichloroethane	3.39 E-7	7.02 E-7	1.36 E-10	9.51 E-14	6.01 E-9
1,1-Dichloroethene	2.52 E-6	5.22 E-6	1.01 E-9	9.32 E-12	3.33 E-8
t-1,2-Dichloroethene	1.32 E-6	2.73 E-6	5.30 E-10	--	1.74 E-8
Tetrachloroethene	7.41 E-8	1.53 E-7	2.98 E-11	7.54 E-16	9.78 E-10
Trichloroethene	3.10 E-7	6.42 E-7	1.25 E-10	1.24 E-14	5.57 E-9
Methylene Chloride	1.74 E-6	3.60 E-6	6.98 E-10	7.66 E-14	4.58 E-9
1,1,1 Trichloroethane	5.16 E-7	1.07 E-6	2.07 E-10	--	1.95 E-9
Chloroform	8.05 E-7	1.67 E-6	3.23 E-10	2.01 E-13	1.06 E-8
1,1 Dichloroethane	9.22 E-7	1.91 E-6	3.70 E-10	--	1.13 E-10
1,1,2 Trichloroethane	9.80 E-8	2.03 E-7	3.94 E-11	1.73 E-14	3.23 E-9
Totals	9.09 E-6			9.91 E-12	1.69 E-7

Exposure duration = 30 years

Liquid Flow Rate = 30 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 1.94 E-4 sec/m^3 (See Appendix I)

[1] See Appendix B.

[2] 3.15 E-6 = 3.15×10^{-6} = 0.000003

Table E-4

RISKS TO THE GENERAL PUBLIC FROM VOCs RELEASED FROM THE COLLECTION TANK VENT

Volatile Organic Chemical	VOC Vapor Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Adult Risk[1]		Child Risk[1]	
				Carcinogenic	Non-Carcinogenic	Carcinogenic	Non-Carcinogenic
Carbon Tetrachloride	3.15 E-6[2]	1.39 E-6	1.24 E-12	2.27 E-14	5.81 E-10	3.04 E-14	1.77 E-9
1,2-Dichloroethane	3.39 E-7	1.50 E-7	1.33 E-13	1.71 E-15	5.88 E-12	2.29 E-15	1.79 E-11
1,1-Dichloroethene	1.29 E-4	5.68 E-5	5.05 E-11	8.54 E-12	1.66 E-9	1.14 E-11	5.05 E-9
t-1,2-Dichloroethene	4.36 E-5	1.93 E-5	1.71 E-11	--	5.63 E-10	--	1.71 E-9
Tetrachloroethene	2.27 E-6	1.00 E-6	8.91 E-13	4.14 E-16	2.93 E-11	5.55 E-16	8.91 E-11
Trichloroethene	2.48 E-5	1.10 E-5	9.75 E-12	1.79 E-14	4.36 E-10	2.39 E-14	1.35 E-9
Methylene Chloride	3.13 E-6	1.38 E-6	1.23 E-12	2.47 E-15	8.07 E-12	3.32 E-15	2.46 E-11
1,1,1 Trichloroethane	4.85 E-5	2.14 E-5	1.91 E-11	--	1.79 E-10	--	5.45 E-10
Chloroform	7.68 E-7	3.39 E-7	3.02 E-13	3.44 E-15	9.91 E-12	4.61 E-15	3.02 E-11
1,1 Dichloroethane	1.11 E-6	4.88 E-7	4.35 E-13	--	1.03 E-12	--	3.15 E-12
1,1,2 Trichloroethane	9.80 E-8	4.33 E-8	3.85 E-14	3.11 E-16	3.16 E-12	4.17 E-16	9.63 E-12
Totals	2.56 E-4			8.59 E-12	3.47 E-9	1.15 E-11	1.06 E-8

Exposure duration = 30 years

Vent discharge rate = 7 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 8.90 E-7 sec/m^3 (See Appendix I)

[1] See Appendix B.

[2] 3.15 E-6 = 3.15×10^{-6} = 0.00000315

Table E-3

RISKS TO SITE EMPLOYEES FROM VOCs RELEASED FROM THE COLLECTION TANK VENT

Volatile Organic Chemical	VOC Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Risk[1]	
				Carcinogenic	Noncarcinogenic
Carbon Tetrachloride	3.15 E-6[2]	6.52 E-6	1.36 E-9	5.69 E-12	6.37 E-7
1,2-Dichloroethane	3.39 E-7	7.02 E-7	1.46 E-10	34.28E-13	6.45 E-9
1,1-Dichloroethene	1.29 E-4	2.66 E-4	5.54 E-8	2.14 E-9	1.82 E-6
t-1,2-Dichloroethene	4.36 E-5	9.03 E-5	1.88 E-8	--	6.17 E-7
Tetrachloroethene	2.27 E-6	4.70 E-6	9.77 E-10	1.04 E-13	3.21 E-8
Trichloroethene	2.48 E-5	5.14 E-5	1.07 E-8	4.48 E-12	4.78 E-7
Methylene Chloride	3.13 E-6	6.47 E-6	1.35 E-9	6.21 E-13	8.85 E-9
1,1,1 Trichloroethane	4.85 E-5	1.00 E-4	2.09 E-8	--	1.96 E-7
Chloroform	7.68 E-7	1.59 E-6	3.31 E-10	8.63 E-13	1.09 E-8
1,1 Dichloroethane	1.11 E-6	2.29 E-6	4.76 E-10	--	1.13 E-9
1,1,2 Trichloroethane	9.80 E-8	2.03 E-7	4.22 E-11	7.80 E-14	3.47 E-9
Totals	2.56 E-4			2.15 E-9	3.81 E-6

Exposure duration = 30 years

Liquid Flow Rate = 7 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 2.08 E-4 sec/m^3 (See Appendix I)

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[1] See Appendix B.

[2] 3.15 E-6 = 3.15×10^{-6} = 0.000003

Table E-2

RISKS TO THE GENERAL PUBLIC FROM VOCs RELEASED DURING EXCAVATION

Volatile Organic Chemical	VOC Vapor Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Adult Risk[1]		Child Risk[1]	
				Carcinogenic	Non-Carcinogenic	Carcinogenic	Non-Carcinogenic
Carbon Tetrachloride	3.00 E-3[2]	3.79 E-4	3.37 E-10	4.73 E-14	1.58 E-7	1.44 E-13	4.81 E-7
1,2-Dichloroethane	3.10 E-3	3.91 E-4	3.48 E-10	3.42 E-14	1.54 E-8	1.04 E-13	4.68 E-8
1,1-Dichloroethene	2.60 E-3	3.28 E-4	2.92 E-10	3.78 E-13	9.59 E-9	1.15 E-12	2.92 E-8
t-1,2-Dichloroethene	2.46 E-3	3.03 E-4	2.70 E-10	--	8.86 E-9	--	2.70 E-8
Tetrachloroethene	4.60 E-3	5.80 E-4	5.17 E-10	1.84 E-15	1.70 E-8	5.60 E-15	5.17 E-8
Trichloroethene	2.40 E-2	3.03 E-3	2.70 E-9	3.78 E-14	1.20 E-7	1.15 E-13	3.67 E-7
Methylene Chloride	3.10 E-3	3.91 E-4	3.48 E-10	5.38 E-15	2.29 E-9	1.64 E-14	6.96 E-9
1,1,1 Trichloroethane	3.00 E-3	3.79 E-4	3.37 E-10	--	3.16 E-9	--	9.63 E-9
Chloroform	2.50 E-3	3.15 E-4	2.81 E-10	2.46 E-14	9.22 E-9	7.48 E-14	2.81 E-8
1,1 Dichloroethane	2.50 E-3	3.15 E-4	2.81 E-10	--	6.68 E-10	--	2.03 E-9
1,1,2 Trichloroethane	2.40 E-3	3.03 E-4	2.70 E-10	1.67 E-14	2.21 E-8	5.08 E-14	6.74 E-8
Totals	5.80 E-2			5.30 E-13	3.45 E-7	1.61 E-12	1.05 E-6

Exposure duration = 60 days

Vent discharge rate = 2 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 8.90 E-7 sec/m^3 (See Appendix I)

[1] See Appendix B.

[2] 3.00 E-3 = 3.00×10^{-3} = 0.003

Table E-1

RISKS TO SITE EMPLOYEES FROM VOCs RELEASED DURING EXCAVATION

Volatile Organic Chemical	VOC Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Risk[1]	
				Carcinogenic	Noncarcinogenic
Carbon Tetrachloride	3.00 E-3[2]	3.79 E-4	2.77 E-8	9.28 E-13	1.30 E-5
1,2-Dichloroethane	3.10 E-3	3.91 E-4	2.78 E-8	6.71 E-13	1.27 E-6
1,1-Dichloroethene	2.60 E-3	3.28 E-4	2.40 E-8	7.42 E-12	7.90 E-7
t-1,2-Dichloroethene	2.40 E-3	3.03 E-4	2.22 E-8	--	7.29 E-7
Tetrachloroethene	4.60 E-3	5.80 E-4	4.25 E-8	3.61 E-14	1.40 E-6
Trichloroethene	2.40 E-2	3.03 E-3	2.22 E-7	7.42 E-13	9.92 E-6
Methylene Chloride	3.10 E-3	3.91 E-4	2.87 E-8	1.05 E-13	1.88 E-7
1,1,1 Trichloroethane	3.00 E-3	3.79 E-4	2.77 E-8	--	2.60 E-7
Chloroform	2.50 E-3	3.15 E-4	2.31 E-8	4.82 E-13	7.60 E-7
1,1 Dichloroethane	2.50 E-3	3.15 E-4	2.31 E-8	--	5.51 E-8
1,1,2 Trichloroethane	2.40 E-3	3.03 E-4	2.22 E-8	3.27 E-13	1.82 E-6
Totals	5.08 E-2			1.04 E-11	2.84 E-5

Exposure duration = 60 days

Liquid Flow Rate = 2 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 7.33 E-5 sec/m^3 (See Appendix I)

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[1] See Appendix B.

[2] 3.00 E-3 = 3.00×10^{-3} = 0.003

APPENDIX E - RISKS FROM EXPOSURE TO AIRBORNE VOCs

Exposure to VOCs Released During Excavation

As noted in the IRAP, it is estimated that following the initial pumpdown, the liquid yield from the french drain would be about two gallons per minute. As a conservative estimate of the source term for VOC vapor released from the trench during construction, it is assumed that even if dewatering is performed, there will be a vapor release equivalent to complete offgassing of vapors from two gallons of water per minute. The concentration of VOCs in the water is assumed to be equal to the average of the well water samples taken in the areas closest to and hydrologically upstream of the trench location. The methods used to estimate the risks to the general public associated with this release path are described in Appendix A. The risk estimates are summarized in Table E-1 for RFP employees not involved with remediation work (site employees) and Table E-2 for members of the general public.

Exposure to VOCs from Collection Tank Venting

In calculating the increased risks from VOCs released from the collection tank vents, it was assumed that the air in the tanks reached equilibrium with liquid with average processing liquid concentration (see Appendix C) and that the vapors are displaced by water at the rate of seven gallons per minute (the design flow rate for the system). The methods used to calculate the risks are described in Appendix A. The risk estimates for individual and total VOCs is shown in Table E-3 for site employees and Table E-4 for members of the general public.

Exposure to VOCs from Processed Water Surge Tank Venting

Small amounts of VOCs may remain in the treated effluent. Some vapors may escape through the effluent surge tank vent. In order to make an upper bound estimate of the risks associated with this pathway, it was conservatively assumed that all of the VOCs were present in the process effluent at the minimum detection limit. It was assumed that the gas space is in equilibrium with the liquid and that the vapors are displaced by water at the treatment design rate of thirty gallons per minute. The risks associated with this exposure route were calculated using the techniques described in Appendix A and are summarized in Table E-5 for site employees and Table E-6 for members of the general public.

Risk Calculation

Carcinogenic Risk

Carcinogenic Risk = CDI x PF x EDA

where:

PF = Potency Factor
= 1.40 E-2 $(mg/kg/day)^{-1}$

EDA = Exposure Duration Adjustment
= (duration of exposure) ÷ average lifetime
= (60 days) ÷ (70 years x 365 days/year)
= 2.35 E-3

Carcinogenic Risk = 9.87 E-10

Noncarcinogenic risk

Acceptable Chronic Intake (HEC)[3]	=	2.00 E-2 mg/kg/day
Ratio of CDI to HEC	=	1.50 E-3

[3] See Appendix B, Noncarcinogenic Risk.

APPENDIX D - RISKS TO WORKERS FROM DERMAL EXPOSURES

Soil-borne organic chemical concentration

Bis(2-ethylhexyl)phthalate: 2,470 $\mu g/kg$[1]

Exposure period: 5 days/week for 12 weeks

Exposure dermal area[2]

Total body surface area		18,000 cm^2
Percent body surface for:	arms and hands 18%	
	lower legs and feet 18%	
	head and neck 9%	
Assumed exposed skin surface		8,100 cm^2

Uptake Calculation

$$CDI = (C \times A \times S \times ABS \times 10^{-6}\ kg/mg) \div BW$$

where:

CDI	=	Chronic Daily Intake of contaminant through the skin
C	=	Concentration of contaminant in the soil ($\mu g/kg$)
A	=	Amount of soil adhering to skin = 1.5 $mg/cm^2/day$
S	=	Exposed skin surface = 8,100 cm^2
ABS	=	Fraction of contaminant absorbed through skin = 0.07
BW	=	Body weight of adult = 70 kg

CDI = 3.3 E-5 mg/kg/day

[1] Average of the boreholes nearest the proposed location of the french drain (BH 2-87, BH 6-87, and BH 13-87). During calculation of averages, when results were less than the minimum detectable levels of analysis, a value of 1/2 the minimum detectable level was used.

[2] Shleien, 1984.

Table C-2
SURGE TANK VAPOR CONCENTRATIONS

Volatile Organic Chemical	Liquid Concentration (mg/l)	Molecular Weight	gram-moles per liter (gmoles/l)[1]	liquid mole-fraction[2]	Vapor Pressure of Pure Chemical (mm Hg)	Vapor Partial Pressure (mm Hg)[3]	Partial Pressure fraction[4]	Vapor Concentration (g/m^3)[5]
Carbon Tetrachloride	5.00 E-3[6]	153.84	3.25 E-8	5.87 E-10	91.15	5.35 E-8	8.91 E-11	4.50 E-7
1,2-Dichloroethane	5.00 E-3	98.97	5.05 E-8	9.12 E-10	68.66	6.26 E-8	1.04 E-10	3.39 E-7
1,1-Dichloroethene	5.00 E-3	96.95	5.16 E-8	9.31 E-10	510.56	4.75 E-7	7.92 E-10	2.52 E-6
t-1,2-Dichloroethene	5.00 E-3	96.95	5.16 E-8	9.31 E-10	267.51	2.49 E-7	4.15 E-10	1.32 E-6
Tetrachloroethene	5.00 E-3	165.85	3.01 E-8	5.44 E-10	15.01	8.17 E-9	1.36 E-11	7.41 E-8
Trichloroethene	5.00 E-3	131.40	3.81 E-8	6.87 E-10	62.85	4.32 E-8	7.19 E-11	3.10 E-7
Methylene Chloride	5.00 E-3	84.93	5.89 E-8	1.06 E-9	351.86	3.74 E-7	6.23 E-10	1.74 E-6
1,1,1 Trichloroethane	5.00 E-3	133.41	3.75 E-8	6.76 E-10	104.57	7.07 E-8	1.18 E-10	5.16 E-7
Chloroform	5.00 E-3	119.38	4.19 E-8	7.56 E-10	162.99	1.23 E-7	2.05 E-10	8.05 E-7
1,1 Dichloroethane	5.00 E-3	98.96	5.05 E-8	9.12 E-10	186.70	1.70 E-7	2.84 E-10	9.22 E-7
1,1,2 Trichloroethane	5.00 E-3	133.41	3.75 E-8	6.76 E-10	19.86	1.34 E-8	2.24 E-11	9.80 E-8
Water	1.00 E+3	18.02	5.54 E+1	1.00 E+0	18.69	1.87 E+1	3.12 E-2	1.84 E+1

[1] gram-moles/liter = liquid concentration. / (molecular weight x 1000 mg/g)

[2] liquid mole-fraction = $(\text{gram-mole / liter})_i \div \Sigma(\text{gram-mole / liter})$

[3] Vapor Partial Pressure = Mole fraction in vapor = Vapor Pressure x liquid mole-fraction (Raoult's Law)

[4] Partial Pressure Fraction = (Vapor Partial Pressure) / (Gas pressure above liquid = Atmospheric Pressure = 600 mm Hg)

[5] Vapor Concentration = Partial Pressure fraction x molecular weight x (N/V)
N/V (from PV = NRT) = 32.82 gmoles / m^3

[6] 5.00 E-3 = 5.00×10^{-3} = 0.005

Table C-1

COLLECTION TANK VAPOR CONCENTRATIONS

Volatile Organic Chemical	Liquid Concentration (mg/l)	Molecular Weight	gram-moles per liter (gmoles/l)[1]	liquid mole-fraction[2]	Vapor Pressure of Pure Chemical (mm Hg)	Vapor Partial Pressure (mm Hg)[3]	Partial Pressure fraction[4]	Vapor Concentration (g/m^3)[5]
Carbon Tetrachloride	3.50 E-2[6]	153.84	2.28 E-7	4.11 E-9	91.15	3.74 E-7	6.24 E-10	3.15 E-6
1,2-Dichloroethane	5.00 E-3	98.97	5.05 E-8	9.12 E-10	68.66	6.26 E-8	1.04 E-10	3.39 E-7
1,1-Dichloroethene	2.55 E-1	96.95	2.63 E-6	4.75 E-8	510.56	2.42 E-5	4.04 E-8	1.29 E-4
t-1,2-Dichloroethene	1.65 E-1	96.95	1.70 E-6	3.07 E-8	267.51	8.22 E-6	1.37 E-8	4.36 E-5
Tetrachloroethene	1.53 E-1	65.85	9.23 E-7	1.66 E-8	15.01	2.50 E-7	4.17 E-10	2.27 E-6
Trichloroethene	4.00 E-1	131.40	3.04 E-6	5.49 E-8	62.85	3.45 E-6	5.75 E-9	2.48 E-5
Methylene Chloride	9.00 E-3	84.93	1.06 E-7	1.91 E-9	351.86	6.73 E-7	1.12 E-9	3.13 E-6
1,1,1 Trichloroethane	4.70 E-1	133.41	3.52 E-6	6.36 E-8	104.57	6.65 E-6	1.11 E-8	4.85 E-5
Chloroform	4.77 E-3	119.38	4.00 E-8	7.21 E-10	162.99	1.18 E-7	1.96 E-10	7.68 E-7
1,1 Dichloroethane	6.00 E-3	98.96	6.06 E-8	1.09 E-9	186.70	2.04 E-7	3.40 E-10	1.11 E-6
1,1,2 Trichloroethane	5.00 E-3	133.41	3.75 E-8	6.76 E-10	19.86	1.34 E-8	2.24 E-11	9.80 E-8
Water	1.00 E+3	18.02	5.54 E+1	1.00 E+0	18.69	1.87 E+1	3.12 E-2	1.84 E+1

[1] gram-moles/liter = liquid concentration. / (molecular weight x 1000 mg/g)

[2] liquid mole-fraction = (gram-mole / liter)$_i$ ÷ Σ(gram-mole / liter)

[3] Vapor Partial Pressure = Mole fraction in vapor = Vapor Pressure x liquid mole-fraction (Raoult's Law)

[4] Partial Pressure Fraction = (Vapor Partial Pressure) / (Gas pressure above liquid = Atmospheric Pressure = 600 mm Hg)

[5] Vapor Concentration = Partial Pressure fraction x molecular weight x (N/V)
N/V (from PV = NRT) = 32.82 gmoles / m^3

[6] 3.50 E-2 = 3.50×10^{-2} = 0.035

Vapor pressure tables for the VOCs provide the boiling point temperatures at specific pressures. The following equation (derived from the relationship of vapor pressure and temperature $\log P = A - (B/T)$ (Perry and Green, 1984) was used to interpolate the data on these tables to get vapor pressure at a given temperature (21° C).

$$\log (P/P_1) = \log (P_2/P_1) \times (T_2/T) \times (T - T_1)/(T_2 - T_1)$$

where:

	P	=	vapor pressure of interest
	T	=	temperature of interest
	P_i	=	vapor pressure at temperature T_i (from published tables).

Table C-1 shows the data used to calculate the vapor concentrations as well as the intermediate results obtained in the calculation of those concentrations.

The VOC release rate from the vented effluent tanks was also estimated using the same method as the influent tank vent. The gas displacement rate used was 30 gpm and the VOC concentrations equal to the minimum detection level (5 E-3 mg/l for each VOC). Table C-2 shows the data used to calculate the vapor concentrations for the effluent tank vent.

APPENDIX C - SOURCE CONCENTRATIONS

The estimation of the release source term (see Appendix A) requires an estimated air concentration which will be based primarily on the concentration of volatile chemicals in the liquid from which they may emanate. For the collection tank vent releases and the accident scenario involving the ruptured collection tank, the VOC concentration used was derived from Table 4-1 of the IRAP and is reproduced in Table C-1. The VOC concentrations in the liquid used in the post-treatment surge tank vent calculation assumes the identified treatment requirements from Table 4-1 or 5×10^{-3} mg/l (the minimum detection limit for most VOCs), whichever is smaller. The assumed VOC concentration from the water exposed during french drain installation is the average concentrations from the wells closest to the proposed drain location (including Wells 2-87, 6-87, 4-87, 50-87, 96-86, and 48-87). If individual VOCs were not reported in a sample, they were included in the calculation of the average concentration at one-half the stated minimum detectable concentration limit.

The VOC release rate from the vented influent tanks was estimated assuming the tanks to be partially filled with the average processing liquid shown in Table C-1 and that the vapors in the gas space above the liquid have reached equilibrium. It is assumed that the vapors are displaced as liquid is added to the tank at the maximum design flow of 8 gpm with no liquids being removed for processing.

The calculation of the VOC vapors in the influent tanks was made using Raoult's Law (Henley, 1959):

$$p_A = P_A x_A$$

where:

	p_A	=	partial pressure of compound A above the solution
	x_A	=	mole fraction of A in solution
	P_A	=	vapor pressure of pure A at the temperature of the solution

The following assumptions were made in the application of Raoult's Law:

1) At the low concentrations involved, even normally immiscible liquids act as if they are in solution.
2) At the very low concentrations involved, each VOC acts as if it were the only compound in solution.

Figure B-1

PUTTING RISK IN PERSPECTIVE

RISK OF DEATH	OCCUPATION	LIFESTYLE	ACCIDENTS	ENVIRONMENTAL RISKS
	STUNTMAN			
1 E-2 or 1 in 100				
	RACE CAR DRIVER	SMOKING One pack/day	ROCK CLIMBING	
1 E-3 or 1 in 1000				
	FARMER		DRIVING MOTOR VEHICLE ALL HOME ACCIDENTS FREQUENT AIR TRAVEL	
1 E-4 or 1 in 10,000				
	TRUCK DRIVING ENGINEER	USING CONTRACEPTIVE PILLS	SKIING HOME FIRE	LIVING DOWNSTREAM OF A DAM NATURAL BACKGROUND RADIATION
1 E-5 or 1 in 100,000				
		DIAGNOSTIC X-RAY	FISHING OCCASIONAL AIR TRAVEL (1 flight/year)	
1 E-6 or 1 in 1,000,000				
		EATING CHARCOAL-BROILED STEAK		
1 E-7 or 1 in 10,000,000				
				ANIMAL BITE OR INSECT STING

Source: (Rockwell International, 1988b)

health criterion (i.e., the ratio exceeds one), it indicates that there is a potential for noncarcinogenic health effects occurring under the defined exposure conditions. Because health criteria incorporate a margin of safety, exceeding a criterion does not necessarily indicate that an adverse effect will occur.

Another difference between the evaluation of noncarcinogenic and carcinogenic risk is that the noncarcinogenic risk is not considered to be cumulative. That is, dose effects are due to the current exposure and are not impacted by previous exposures. Therefore, the assessment of noncarcinogenic risk for the child is carried out separately from, and is not additive to, the assessment for the adult.

The differences in methodology used in assessing noncarcinogenic and carcinogenic risk are based on the assumptions that noncarcinogenic health effects are threshold phenomena, whereas carcinogenic risk is not. This approach for evaluating carcinogenic risk conservatively assumes that for a carcinogen, exposure to even a small number of molecules (possibly even a single molecule) might potentially cause cellular changes that can result in cancer. For noncarcinogens, however, the assumption is made that a threshold level of intake must be exceeded before the potential exists for adverse health effects. HECs are recommended thresholds which should not be exceeded.

Comparison to Other Risks

All human activities are associated with some degree of risk. For the sake of perspective, the risk of death associated with various occupations, personal habits, lifestyles, and accidents are presented in Figure B-1.

General Public

In calculating risks to the general public in this report, the estimates of exposure are performed considering an appropriate individual (i.e., child or adult) that is presumed to remain at the point of highest potential exposure (usually the site boundary) at all times -- 24 hours per day, 365 days per year -- and makes ordinary use of the contaminated media to the greatest extent possible. For example, this hypothetical individual could breath only air at the highest average contamination level that might reach the site boundary or eat vegetables from their garden which is assumed to be planted at the point of highest exposure to contaminants and watered with water as released from the plant site. Thus, the estimate of exposure or risk to the general public represents the maximum a member of the general public could receive, not what any segment of the population might be expected to receive.

Hazardous Chemical

Any chemicals designated as a hazardous substance by federal regulations as found in the Code of Federal Regulations, Title 40, Part 116.

Institutional Control

As used in this report, institutional control refers to administrative and legal control over a specified portion of land such that access to and use of the land is maintained by a recognized agency of the government.

Noncarcinogenic Risk

The noncarcinogenic risk is the estimate of whether a given concentration of a chemical may cause a noncancerous health effect in an individual exposed to it.

Noncarcinogenic risk was evaluated by comparing predicted contaminant daily intakes to Health Effects Criteria (HEC). HEC used in this report are Reference Doses (RfDs) as developed by the Environmental Protection Agency or a calculated equivalent if no RfD has been adopted by the EPA. It is important to note that the approach used in assessing potential noncarcinogenic health effects, unlike the approach used in the evaluation of carcinogenic risk in Section 5.1, is not a measure of, and cannot be used to determine, quantitative risk (i.e., it does not predict the relative likelihood of adverse effects occurring). If the estimated daily intake of a contaminant exceeds the applicable

APPENDIX B - SPECIAL TERMS USED IN THIS REPORT

Carcinogenic Risk

The carcinogenic risk or the cancer risk factor provides an estimate of the additional incidence of cancer that may be expected in a population exposed to a given contaminant. A risk of 10^{-5}, for example, indicates a probability of one additional case of cancer for every 100,000 people exposed. A risk of 10^{-6} indicates one additional case of cancer for every one million people exposed. A risk of 10^{-7} would be one case in 10 million people exposed (EPA, 1985).

The carcinogenic risk posed by exposure to a chemical depends upon three factors: dosage (estimated daily intake), the carcinogenic potency of the chemical (Potency Factor), and the exposure duration.

The carcinogenic potency of a substance depends, in part, upon its route of entry into the body (e.g., ingestion, inhalation, or dermal). Therefore, Potency Factors (PFs) are classified according to the route of administration that is applicable to the experimental or epidemiological data from which they were derived. The EPA has developed potency factors for the oral and/or inhalation routes for some carcinogens.

The length of exposure to a chemical must also be taken into account in the calculation of carcinogenic risk since carcinogenic potency factors are based on an exposure duration of 70 years (average lifetime exposure), and carcinogenic risk is assumed to be proportional to exposure duration (Rockwell, 1988b).

Contaminant

In the context of this report, contaminants refer to the hazardous substances (as designated in 40CFR116) or radioactive material found in air, water, or soil in quantities in excess of its occurrence in the local environment or in excess of applicable regulations.

Table A-1
HAZARDOUS CHEMICAL PARAMETERS

Chemical	Potency Factor[1]	Health Effects Criteria[1]
Carbon Tetrachloride	1.30 E-1[2,3]	7.00 E-4[4]
1,2-Dichloroethane	9.10 E-2[5]	1.00 E-2[6]
1,1-Dichloroethene	1.20 E-0[5]	1.00 E-2[4]
t-1,2-Dichloroethene	0[7]	1.00 E-2[4]
Tetrachloroethene	3.30 E-3[5]	1.00 E-2[5]
Trichloroethene	1.30 E-2[5]	7.35 E-3[4]
Methylene Chloride	1.43 E-2[3]	5.00 E-2[4]
1,1,1 Trichloroethane	0[7]	3.50 E-2[4]
Chloroform	8.10 E-2[3]	1.00 E-2[8]
1,1 Dichloroethane	0[9]	1.38 E-1[3]
1,1,2 Trichloroethane	5.73 E-2[3]	4.00 E-3[5]
Bis(2-ethylhexyl)phthalate	1.40 E-2[5]	2.00 E-2[7]
Manganese	0[7]	2.20 E-1[5](Oral)
		3.00 E-4[3](Inhalation)
Mercury	0[7]	3.00 E-4[5](Oral)
		5.10 E-5[3](Inhalation)
Nickel	0[7](Oral)	2.00 E-2[5](Oral)
	1.19[9](Inhalation)	NA (Inhalation)
Selenium	0[7]	3.00 E-3[5](Oral)
		1.00 E-3[5](Inhalation)

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[1]See Appendix B, _Carcinogenic Risk_.

[2]1.30 E-1 = 1.30×10^{-1} = 0.13

[3]HEA (EPA, 1986)

[4]RfD (EPA, 1987a)

[5]RfD (EPA, 1989)

[6]Calculated, TAD/1000, see (EPA, 1987a)

[7](EPA, 1989)

[8]RfD (EPA, 1986)

[9](EPA, 1986)

For intakes which occur due to drinking contaminated water, the following equation is used to estimate the Chronic Daily Intake:

$$CDI = (C_{water} \times IR) \div BW$$

where CDI and BW are as defined previously and:

C_{water} = Average concentration in drinking water (mg/l)

IR = Ingestion Rate of liquids
= 1.95 l/day (adult)[3]
= 1.40 l/day (child)[3]

The concentration of contaminant after dilution in a body of water may be calculated using the following equation:

$$C_{water} = (C_{influent} \times V_{influent}) \div (V_{receptor} + V_{influent})$$

where:

$C_{influent}$ = Average concentration in the water before dilution in the body of water

$V_{influent}$ = Volume of contaminated water flowing into the body of water

$V_{receptor}$ = Volume of water in the receiving body prior to introducing the contaminated water

Table A-1 lists the values for PF and HEC for each of the hazardous chemicals used in this report.

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[3](ICRP 23)

$$BW = \text{Body Weight}$$
$$= 70 \text{ kg (adult)}^2$$
$$= 15 \text{ kg (child)}^2$$

EDA = Exposure Duration Adjustment

= (hours per day the source is releasing ÷ 24) x (days per week the source is releasing ÷ 7) x (duration of the exposure in years ÷ 70)

For adults, the exposure duration is 30 years. For children, there are two components: the first five years when a child's body mass and breathing rate are used for analysis (5/70) and the remaining twenty-five years when it is assumed the breathing rate and body mass are equal to those of an adult (25/70). The total lifetime risk of a child is the combined risks for these two components.

The following formula is used to calculate the air concentration at some point distant from the place the contaminant is released to the air:

$$C_{air} = X/Q \times \text{Release Source Term}$$

where:

X/Q = dispersion factor (see Appendix I)

Release Source Term = Rate at which the contaminated material is released (mg/sec).

For example, in the case of gases being displaced by liquids entering a tank,

$$\text{Release Source Term} = (FR \times SC \times 3.7853 \text{ l/gal}) \div 60 \text{ sec/min}$$

where:

FR = Flow rate at which the gases are being displaced (gal/min)

SC = Source concentration (mg/l)

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[2](ICRP 23)

APPENDIX A - RISK ESTIMATION TECHNIQUES

Carcinogenic risks are calculated to estimate the increased likelihood of an individual contracting a carcinogenic disease during his lifetime due to the uptake being evaluated.

$$\text{Cancer Risk} = \text{PF} \times \text{CDI}$$

where:

PF = Carcinogenic Potency Factor, as defined in the Superfund Public Health Evaluation Manual (EPA, 1986)

CDI = Chronic Daily Intake

Non-carcinogenic risk assessment is made by comparing the chronic daily intake (CDI) to an uptake level (called the Health Effects Criterion or HEC) below which it is not expected that any health effects are likely to occur.

$$\text{Risk Assessment Ratio} = \text{CDI} \div \text{HEC}$$

For intakes which occur due to inhalation of contaminated air, the following equation is used to estimate the Chronic Daily Intake:

$$\text{CDI (mg/kg/day)} = (C_{air} \times \text{BR} \times \text{EDA}) \div \text{BW}$$

where:

C_{air} = Average concentration in air (mg/m^3) at the point of exposure.

BR = Breathing Rate
= 23 m^3/day (adult)[1]
= 15 m^3/day (child)[1]

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[1](ICRP 23)

(Rao, 1982) Rao, R.K., E.L. Wilmot, and R.E. Luna, Non-Radiological Impact of Transporting Radioactive Material, SAND81-1703, TTC-0236, Sandia National Laboratories, Albuquerque, NM, 1982.

(Rockwell, 1987) U.S. Department of Energy, Draft Remedial Investigation Report for High Priority Sites (881 Hillside Area), Volume I through V. Rocky Flats Plant, Golden, Colorado, July 1, 1987.

(Rockwell, 1988a) U.S. Department of Energy; Draft Feasibility Study Report For High Priority Sites (881 Hillside Area); Volume I. Rocky Flats Plant, Golden, Colorado, 1 March, 1988.

(Rockwell, 1988b) U.S. Department of Energy; Draft Feasibility Study Report For High Priority Sites (881 Hillside Area); Volume II - Appendices. Rocky Flats Plant, Golden, Colorado, 1 March 1988.

(Rockwell, 1988c) U.S. Department of Energy; Final Draft Remedial Investigation Report For High Priority Sites (881 Hillside Area); Volume 1. Rocky Flats Plant, Golden, Colorado, 1 March 1988.

(Shleien, 1984) Shleien, Bernard and Michael S. Terpilak, The Health Physics and Radiological Health Handbook. Olney, Maryland: Nucleon Lectern Associates, Inc., 1984, p. 216.

(USFWS, 1988) Letter from Jeffrey D. Opdycke to George W. Campbell, U.S. Fish and Wildlife Service, 15 March, 1988.

(EPA, 1986) Environmental Protection Agency; Superfund Public Health Evaluation Manual, PB87-183125, Washington, D.C., October, 1986.

(EPA, 1987) Environmental Protection Agency; Interim Recommendations on Doses to Persons Exposed to Transuranium Elements in the General Environment, Washington, D.C., July, 1987

(EPA, 1987a) Environmental Protection Agency; Health Advisories for 25 Organics, PB87-235578, Washington, D.C., 1987.

(EPA, 1988) U.S. Environmental Protection Agency; Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, EPA-520/1-88-020, Washington, D.C., September, 1988.

(EPA, 1989) Environmental Protection Agency; Health Effects Assessment Summary Tables, 2nd Quarter, FY1989, OERR 9200.6-303(89-2), Washington, D.C., April, 1989.

(Gifford, 1976) Gifford, F.A., Jr., "Turbulent Diffusion - Type Schemes: A Review," Nuclear Safety 17(1): 68-86, February, 1976.

(Henley, 1959) Henley, E.J., and H. Bieber, Chemical Engineering Calculations. McGraw-Hill Book Co., Inc., 1959, p. 46.

(ICRP 23) International Commission of Radiological Protection, Reference Man: Anatomical, Physiological and Metabolic Characteristics, ICRP Publication No. 23, Pergammon Press, Elmsford, New York.

(NEPA, 1969) The National Environmental Policy Act of 1969; Public Law 91-190, 42 USC 4321-4347, January 1, 1970, as amended by Public Law 94-52, July 3, 1975, and Public Law 94-83, August 9, 1975.

REFERENCES

(DOE, 1980) U.S. Department of Energy; Final Environmental Impact Statement: Rocky Flats Plant Site, Golden, Jefferson County, Colorado, Volumes 1, 2, and 3, DOE/EIS-0064; Washington, D.C., April, 1980.

(DOE, 1988a) Letter from George W. Campbell (Rockwell International, Rocky Flats Plant) to A.E. Whiteman (DOE, Rocky Flats Area Office); titled "Archaeological and Historic Resource Clearance Documentation for 903 Pad and 881 Hillside Cleanups", July 15, 1988.

(DOE, 1988b) U.S. Department of Energy; Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, Washington, D.C., July, 1988.

(DOE, 1988c) U.S. Department of Energy; Radiation Protection for Occupational Workers, DOE Order 5480.11, Washington, D.C., December, 1988.

(DOE, 1989) U.S. Department of Energy; Radiation Protection of the Public and the Environment (Draft), DOE Order 5400.XX, Washington, D.C., May, 1989.

(DOE, 1990) U.S. Department of Energy; Interim Measures/Interim Remedial Action Plan and Decision Document/881 Hillside Area/Operable Unit No. 1; Volumes I and II. Rocky Flats Plant, Golden, Colorado, January, 1990.

(EPA, 1985) Environmental Protection Agency; Superfund Programs, Hazardous Substances Response; Code of Federal Regulations Title 40 (Protection of Environment), Chapter 1, Subchapter J, Part 300, Subpart F as of July 1, 1986.

(EPA, 1985b) Environmental Protection Agency; Criteria Document for Uranium in Drinking Water, Criteria and Standards Division, PB 86-241049, Washington, D.C., 1985.

Table E-6

RISKS TO THE GENERAL PUBLIC FROM VOCs RELEASED FROM THE EFFLUENT SURGE TANK VENT

Volatile Organic Chemical	VOC Vapor Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Adult Risk[1]		Child Risk[1]	
				Carcinogenic	Non-Carcinogenic	Carcinogenic	Non-Carcinogenic
Carbon Tetrachloride	4.50 E-7[2]	8.52 E-7	1.49 E-13	6.50 E-16	7.00 E-11	8.71 E-16	2.13 E-10
1,2-Dichloroethane	3.39 E-7	6.41 E-7	1.12 E-13	3.42 E-16	4.96 E-12	4.59 E-16	1.51 E-11
1,1-Dichloroethene	2.52 E-6	4.77 E-6	8.35 E-13	3.36 E-14	2.74 E-11	4.50 E-14	8.35 E-11
t-1,2-Dichloroethene	1.32 E-6	2.50 E-6	4.37 E-13	--	1.44 E-11	--	4.37 E-11
Tetrachloroethene	7.41 E-8	1.40 E-7	2.45 E-14	2.72 E-18	8.07 E-13	3.64 E-18	2.45 E-12
Trichloroethene	3.10 E-7	5.87 E-7	1.03 E-13	4.48 E-17	4.59 E-12	6.00 E-17	1.40 E-11
Methylene Chloride	1.74 E-6	3.29 E-6	5.75 E-13	2.76 E-16	3.78 E-12	3.70 E-16	1.15 E-11
1,1,1 Trichloroethane	5.16 E-7	9.77 E-7	1.71 E-13	--	1.60 E-12	--	4.88 E-12
Chloroform	8.05 E-7	1.52 E-6	2.66 E-13	7.24 E-16	8.76 E-12	9.70 E-16	2.66 E-11
1,1 Dichloroethane	9.22 E-7	1.74 E-6	3.05 E-13	--	7.27 E-13	--	2.21 E-12
1,1,2 Trichloroethane	9.80 E-8	1.86 E-7	3.25 E-14	6.24 E-17	2.67 E-12	8.36 E-17	8.12 E-12
Totals	9.09 E-6			3.57 E-14	1.40 E-10	4.78 E-14	4.25 E-10

Exposure duration = 30 years

Vent discharge rate = 30 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 1.75 E-7 sec/m^3 (See Appendix I)

[1] See Appendix B.

[2] 3.15 E-6 = 3.15×10^{-6} = 0.00000315

APPENDIX F - EXPOSURES TO FUGITIVE DUSTS

Average air contamination levels to which workers involved in the remedial activities may be exposed can be calculated for radioactive material from the following equation:

$$C_{air} = C_s \times L_d \times K$$

where:

C_{air} = Average air contamination (μCi/ml)

C_s = Average soil concentration (μCi/gm)

L_d = Average airborne dust loading (mg/meter^3)

K = Units conversion factor

= 10^{-3} gm/mg

Because it is expected that all activities will conform to the OSHA limit of 10 mg/m^3 for nuisance dust loading in the work place, L_d is assumed to be 10 mg/m^3 at the work site in all the following calculations. None of the following calculations take any credit for percentage of dust that is respirable, ie., all calculations assume 100% of the dust generated is respirable.

For other hazardous or toxic materials, the same equation applies where:

C_{air} = Average air contamination (mg/m^3)

C_s = Average soil concentration (mg/kg)

L_d = Average airborne dust loading (mg/m^3)

K = Units conversion factor

= 10^{-6} kg/mg

For DEHP (the only organic reported in soil samples that would be of concern for fugitive dust inhalation), the calculations are performed as described in Appendix A.

Analyses were also performed on manganese, mercury, nickel, and selenium, the metals that were reported as exceeding ARARs in water samples. Average levels of these metals were determined from the chemical analysis of soil taken from the boreholes nearest the proposed location of the french drain trench as reported in the Remedial Investigation Report (Rockwell, 1988c).

The analysis of radionuclide exposure requires the total uptake of each radionuclide during the exposure period rather than the chronic daily intake (CDI) used for other analyses. The total intake of each radionuclide is calculated by the following equation:

$$I = C_{air} \times BR \times EDA$$

where:

I = Total intake (μCi)

C_{air} = Average air contamination ($\mu Ci/m^3$)

BR = Adult Breathing Rate

= $9.6\ m^3$*

EDA = Exposure Duration Adjustment (the number of days the dust is being generated (60) x 8/24 x 5/7)

= 14.3 days

The fifty-year committed effective dose equivalent (CEDE) is calculated by multiplying the total uptake, I, by the appropriate inhalation dose conversion factor for workers (EPA, 1988) or the general public (DOE, 1988b).

Table F-1 shows the results of the risk evaluations for workers involved in the remedial action. All reported values for manganese and selenium in soil were below the minimum

*Total air breathed in an eight-hour shift (ICRP 23).

detectable limit so no analysis of risk is reported for these metals.

Exposures of members of the public must factor in the effects of atmospheric dispersion that occurs between the place where the dust is generated and the location of the member of the public. The average air concentration is calculated using the following formula:

$$C_{air} = S \times C_s \times X/Q \times K$$

where:

C_{air} = Average air contamination (mg/m^3 or μCi/ml)

S = Source term or rate of dust generation (mg of soil/sec)

C_s = Average soil concentration (mg/kg or μCi/gm)

X/Q = Dispersion factor (sec/m^3)[1]

K = Units conversion factor
= 10^{-3} gm/mg or 10^{-6} kg/mg (whichever is needed to correct for units)

The use of X/Q for the dispersion factor requires a source term in amount of material per unit time (mg/sec or μCi/sec). To estimate that source term, it was assumed that a dust loading of 10 mg/m^3 (the OSHA limit for nuisance dusts) is maintained at the work area over a cross-sectional area four meters high and ten meters long (chosen as the largest dust cloud likely to be maintained during excavation) which, at 3 meters per second wind velocity, would dictate a source term of 1,200 mg of soil per second using the equation:

$$S = H_{cloud} \times W_{cloud} \times u_{avg} \times L_d$$

where

S = Release source term (mg of soil/sec)

---

[1]See Appendix I

H_{cloud} = Height of dust cloud (m)

W_{cloud} = Width of dust cloud (m)

u_{avg} = Average wind speed (m/sec)

L_d = Average airborne dust loading (mg of soil/m^3)

The source term is a linear function of the wind speed but the value of X/Q is an inverse function of the wind speed (see Appendix I) so the resulting air concentrations at locations remote from the work area are not a function of the wind speed.

Table F-2 shows the results of the analyses for exposures of the general public to fugitive dusts.

Table F-1

RISKS TO REMEDIAL WORKERS FROM FUGITIVE DUSTS

Hazardous Material	Soil Concentration	Air Concentration	Inhalation Dose Conversion Factor[1]	Carcinogenic Risk[2]	Noncarcinogenic Risk[2]	Committed Effective Dose Equivalent
Bis-(2-ethylhexyl)phthalate	2.47 E 0 mg/kg[3,4]	2.47 E-5 mg/m^3	NA[5]	1.16 E-8	9.66 E-5	NA
Uranium	2.64 E-4 μCi/gm	2.64 E-6 $\mu Ci/m^3$	1.32 E+2 Rem/μCi	NA	NA	4.78 E-2 Rem
Plutonium	1.63 E-6 μCi/gm	1.63 E-8 $\mu Ci/m^3$	3.08 E+2 Rem/μCi	NA	NA	2.95 E-4 Rem
Mercury	2.60 E-1 mg/kg[4]	2.60 E-6 mg/m^3	NA	0	3.99 E-3	NA
Nickel	1.43 E+1 mg/kg[4]	1.43 E-4 mg/m^3	NA	5.70 E-6	0	NA

Exposure duration = 60 days

Airborne dust loading = 10 mg/m^3

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[1](EPA, 1988)

[2] See Appendix B.

[3] 2.47 E 0 = 2.47×10^{0} = 2.47

[4] Average of the boreholes nearest the proposed location of the french drain (BH 2-87, BH 6-87, and BH 13-87). During calculation of averages, when results were less than the minimum detectable levels of analysis, a value of 1/2 the minimum detectable level was used.

[5] Not Applicable

Table F-2

RISKS TO THE GENERAL PUBLIC FROM FUGITIVE DUSTS

Hazardous Material	Soil Concentration	Air Concentration	Inhalation Dose Conversion Factor[1]	Carcinogenic Risk[2]	Noncarcinogenic Risk[2]	Committed Effective Dose Equivalent
Bis-(2-ethylhexyl)phthalate	2.47 E 0 mg/kg[3,4]	2.64 E-9 mg/m^3	NA[5]	1.66 E-12	1.32 E-7	NA
Uranium	2.64 E-4 μCi/gm	2.82 E-10 $\mu Ci/m^3$	1.30 E+5 mRem/μCi	NA	NA	5.03 E-3 mRem
Plutonium	1.63 E-6 μCi/gm	1.74 E-12 $\mu Ci/m^3$	3.30 E+5 mRem/μCi	NA	NA	7.88 E-5 mRem
Mercury	2.60 E-1 mg/kg[4]	2.78 E-10 mg/m^3	NA	0	5.44 E-6	NA
Nickel	1.43 E+1 mg/kg[4]	1.53 E-8 mg/m^3	NA	8.16 E-10	0	NA

Exposure duration = 60 days

Airborne soil source term = 1200 mg/sec

Dispersion factor (X/Q) = 8.90 E-7 sec/m^3

---

[1](DOE, 1988b)

[2] See Appendix B.

[3] 2.47 E 0 = 2.47 x 10^{0} = 2.47

[4] Average of the boreholes nearest the proposed location of the french drain (BH 2-87, BH 6-87, and BH 13-87). During calculation of averages, when results were less than the minimum detectable levels of analysis, a value of 1/2 the minimum detectable level was used.

[5]Not Applicable

APPENDIX G - RISKS RESULTING FROM ACCIDENT EVENTS

The most severe credible accident with potential for the exposure of the general public would be the rupture of one of the 15,000 gallon influent tanks[1], releasing its contents to the pad on which it is located, with the subsequent offgassing of the liquid contents. Spread of the water would be confined to the pad by the dike surrounding the pad. Other accidents, such as a pipe rupture, would release the tank contents more slowly, decreasing the acute risks, and leaving the carcinogenic risks unchanged. Appendix A describes the techniques used to estimate the risks associated with this type of accident while Appendix C describes the estimation of the liquid source term used. The rate of offgassing from the spilled liquid is very difficult to determine. Since carcinogenic risks are based on the total uptake, the rate of release is not significant. The Health Effect Criteria are specified for daily uptakes. If it is assumed that all the dissolved VOCs are released to the air over the first twenty-four hours and that the uptake by the most critical member of the public extends over the same period, any release rate that releases the liquid in twenty-four hours may be used without changing the risk estimation. It is assumed that the liquid is released at 10.417 gpm (15,000 gallons in 24 hours) in the risk calculations.

Table G-1 summarizes the estimated risks to site employees from a collection tank rupture calculated using these accident conditions. Table G-2 summarizes the estimated risks to the general public from the rupture of a collection tank.

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[1]Rupture of one of the 115,00-gallon effluent surge tanks poses lower health risks. The volume released is greater but the lower concentrations of VOCs in the liquid more than offset the increase in volume released.

Table G-1

RISKS TO SITE EMPLOYEES FROM A TANK RUPTURE ACCIDENT

Volatile Organic Chemical	VOC Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Risk[2]	
				Carcinogenic	Non-carcinogenic
Carbon Tetrachloride	3.50 E-2[3]	2.30 E-2	4.72 E-4	3.94 E-10	2.21 E-1
1,2-Dichloroethane	5.00 E-3	3.29 E-3	6.74 E-5	3.94 E-11	2.97 E-3
1,1-Dichloroethene	2.55 E-1	1.68 E-1	3.44 E-3	2.65 E-8	1.13 E-1
t-1,2-Dichloroethene	1.65 E-1	1.08 E-1	2.22 E-3	--	7.31 E-2
Tetrachloroethene	1.53 E-1	1.01 E-1	2.06 E-3	4.37 E-11	6.77 E-2
Trichloroethene	4.00 E-1	2.63 E-1	5.39 E-3	4.50 E-10	2.41 E-1
Methylene Chloride	9.00 E-3	5.91 E-3	1.21 E-4	1.11 E-11	7.97 E-4
1,1,1 Trichloroethane	4.70 E-1	3.09 E-1	6.33 E-3	--	5.94 E-2
Chloroform	4.77 E-3	3.13 E-3	6.43 E-5	3.35 E-11	2.11 E-3
1,1 Dichloroethane	6.00 E-3	3.94 E-3	8.08 E-5	--	1.92 E-4
1,1,2 Trichloroethane	5.00 E-3	3.29 E-3	6.74 E-5	2.48 E-11	5.53 E-3
Totals	1.51 E+0			2.75 E-8	7.19 E-1

Exposure duration = 24 hours

Liquid flow rate = 10.417 gpm

Operating time adjustment = 1

Dispersion Factor (X/Q) = 2.05 E-2 sec/m^3 (See Appendix I)

[2]See Appendix B, Specific Risk Estimation Terms

[3] 3.50 E-2 = 3.50×10^{-2} = 0.035

Table G-2

RISKS TO THE GENERAL PUBLIC[1] FROM A TANK RUPTURE ACCIDENT

Volatile Organic Chemical	VOC Vapor Concentration (mg/l)	Source Term (mg/sec)	Air Concentration (mg/m^3)	Adult Risk[2]		Child Risk[2]	
				Carcinogenic	Non-Carcinogenic	Carcinogenic	Non-Carcinogenic
Carbon Tetrachloride	3.50 E-2[3]	2.30 E-2	1.05 E-6	1.76 E-12	4.93 E-4	5.35 E-12	1.50 E-3
1,2-Dichloroethane	5.00 E-3	3.29 E-3	1.50 E-7	1.76 E-13	6.63 E-6	5.35 E-13	2.02 E-5
1,1-Dichloroethene	2.55 E-1	1.68 E-1	7.66 E-6	1.18 E-10	2.52 E-4	3.60 E-10	7.66 E-4
t-1,2-Dichloroethene	1.65 E-1	1.08 E-1	4.96 E-6	--	1.63 E-4	--	4.96 E-4
Tetrachloroethene	1.53 E-1	1.01 E-1	4.59 E-6	1.95 E-13	1.51 E-4	5.93 E-13	4.59 E-4
Trichloroethene	4.00 E-1	2.63 E-1	1.20 E-5	2.01 E-12	5.37 E-4	6.11 E-12	1.63 E-3
Methylene Chloride	9.00 E-3	5.91 E-3	2.70 E-7	4.97 E-14	1.78 E-6	1.51 E-13	5.41 E-6
1,1,1 Trichloroethane	4.70 E-1	3.09 E-1	1.41 E-5	--	1.33 E-4	--	4.03 E-4
Chloroform	4.77 E-3	3.13 E-3	1.43 E-7	1.49 E-13	4.71 E-6	4.54 E-13	1.43 E-5
1,1 Dichloroethane	6.00 E-3	3.94 E-3	1.80 E-7	--	4.29 E-7	--	1.31 E-6
1,1,2 Trichloroethane	5.00 E-3	3.29 E-3	1.50 E-7	1.11 E-13	1.23 E-5	3.37 E-13	3.75 E-5
Totals	1.51 E+0			1.23 E-10	1.60 E-3	3.73 E-10	4.88 E-3

Exposure duration = 24 days

Vent discharge rate = 10.417 gpm

Exposure time adjustment = 1

Dispersion Factor (X/Q) = 4.57 E-5 sec/m^3 (See Appendix I)

[1] In order to estimate the maximum exposure or risk to the general public, all estimates are based on the exposure to a person at the site boundary location having the highest airborne concentration and remaining there 24 hours per day, 365 days per year.

[2] See Appendix B, Specific Risk Estimation Terms.

[3] 3.50 E-2 = 3.50×10^{-2} = 0.035

Table J-1

RISKS TO REMEDIATION WORKERS FROM INADVERTENT INGESTION OF SOIL

Hazardous Material	Soil Concentration	Daily Intake	Dose Conversion Factor	Carcinogenic Risk	Noncarcinogenic Risk	Committed Effective Dose Equivalent
Bis-(2-ethylhexyl)phthalate	2.47 E 0 mg/kg[1,2]	1.76 E-7 mg/kg/day	NA[3]	5.80 E-12	8.82 E-6	NA
Uranium	2.64 E-4 μCi/gm	1.32 E-6 μCi/day	2.67 E-2 Rem/μCi	NA	NA	2.11 E-6 Rem
Plutonium	1.63 E-6 μCi/gm	8.15 E-9 μCi/day	3.54 E 0 Rem/μCi	NA	NA	1.74 E-6 Rem
Mercury	2.60 E-1 mg/kg[3]	1.86 E-8 mg/kg/day	NA	0	6.19 E-5	NA
Nickel	1.43 E+1 mg/kg[3]	1.02 E-6 mg/kg/day	NA	0	5.10 E-5	NA

Ingestion rate = 5 mg/day

[1] 2.47 E 0 = 2.47×10^{0} = 2.47

[2] Average of the boreholes nearest the proposed location of the french drain (BH 2-87, BH 6-87, and BH 13-87). During calculation of averages, when results were less than the minimum detectable levels of analysis, a value of 1/2 the minimum detectable level was used.

[3] Not Applicable

APPENDIX H - TRANSPORTATION RISK ESTIMATES FOR ALTERNATIVES

Major quantities of materials to be shipped for each alternative retained for environmental assessment evaluation, as well as a summary of related transportation activities, are presented in Table H-1. It was assumed that bulk material shipments would be made with haul trucks having a 15-yd^3 capacity, that any on-site transport of contaminated groundwater would be by dedicated 7,500- gallon tanker trailer, and that any excavated materials would be retained on-site and utilized as fill material at the remedial sites and would not require transport to another location. A comparison of potential transportation impacts of the proposed action and alternatives is summarized in Table H-2. Due to the relatively small size of construction/operation associated with the alternatives, impacts on plant traffic levels from construction equipment movement and support personnel would be minimal and would not vary greatly among the alternatives.

As presented in Section 5.8, estimates of health effects resulting from transportation have been evaluated (Rao, 1982). Assuming local truck shipments of bulk materials (except bentonite) originate within 50 miles of the plant and that travel is primarily within the metropolitan area, risks associated with one shipment (round-trip) would be:

		Chance of one additional health effect per shipment
Latent Cancer Fatalities*	1.6 E-5	1 in 62,500
Traumatic Injuries	8.2 E-5	1 in 12,200
Traumatic Fatalities	4.8 E-6	1 in 208,000

* from increased vehicle pollution

Shipments of bentonite (slurry wall) are assumed to originate from Wyoming, with a one-way distance of 280 miles. It is estimated that 20% of the travel is within urban areas. Risks associated with one round-trip shipment would be:

		Chance of one additional health effect per shipment
Latent Cancer Fatalities*	1.8 E-5	1 in 55,480
Traumatic Injuries	4.6 E-4	1 in 2,170
Traumatic Fatalities	2.7 E-5	1 in 36,990

* from increased vehicle pollution

The hazardous nature of the cargo being transported is another factor that must also be considered. Quantities and concentrations of contaminated materials to be shipped by the various alternatives are quite small compared with the estimated 100 million shipments of hazardous commodities made annually within the nation and will have negligible impacts on a local or regional basis. Any such shipments would be in accordance with applicable regulations (e.g., DOT, DOE).

If, during construction activities for any of the alternatives, areas of localized radioactive contamination are identified and excavated as discussed in Section 5.5.1, the associated impacts due to transportation of the excavated material would be essentially the same as described in Section 6.8.3 of this report. It is not anticipated that more than a single shipment would be involved, so the attendant risks would not present a major impact to the public.

Table H-1

SUMMARY OF REMEDIAL ACTION ALTERNATIVE TRANSPORTATION PARAMETERS

Alternative	Material to be Transported	Estimated[1] Volume of Material (yd^3)	Estimated[2] Number of Truck Shipments	Comments
No Action	None	0	0	No transportation involved.
Immobilization	Grout	920	61	Shipments would occur only during construction phase.
	Grout Pipe/ Drilling Equipment	--	10	
Total Encapsulation	Slurry Wall Material	1,685	112	Shipments would primarily occur during the construction phase. Would involve on-site shipments of contaminated groundwater. Bentonite for the slurry wall will come from Wyoming, involving longer trips than for most other materials.
	Cap Material			
	- compacted soil	3,407	227	
	- drain rock	851	57	
	- top soil	850	57	
	Misc. (e.g., pumps/ sumps, fabric)	--	10	
	Collected Contaminated Groundwater	--	50 initially 1 annually	
Source Well and Footing Drain Collection with Treatment	Treatment Plant Equipment	--	20	Shipments would primarily occur during the construction phase. Periodic shipments of treatment consumables would be required during operation.
	Treatment Plant Consumables - hydrogen peroxide	--	2-3 annually	
	Drain Rock	3,667	245	
	Sump Pump/Misc. Equip.	--	10	
Comprehensive Well Array and Treatment	Treatment Plant Equipment	--	20	Shipments would primarily occur during the construction phase, with periodic shipments of treatment consumables.
	Treatment Plant Consumables - hydrogen peroxide		2-3 annually	
	Drain Rock	3,667	245	
	Well System Equip.	--	15	

Notes: [1] Material volume estimates are based on (Rockwell, 1988a).
[2] Assumes 15-yd^3 capacity for haul trucks and 7,500-gallon tanker trailer capacity for on-site shipments of contaminated water.

Table H-1 (cont.)

SUMMARY OF REMEDIAL ACTION ALTERNATIVE TRANSPORTATION PARAMETERS

Alternative	Material to be Transported	Estimated[1] Volume of Material (yd^3)	Estimated[2] Number of Truck Shipments	Comments
French Drain and Soil Flushing	Treatment Plant Equipment	--	20	Transportation activities similar to proposed action, but a larger number of shipments are required due to the addition of a leach field.
	Treatment Plant Consumables - hydrogen peroxide		2-4 annually	
	Drain Rock	11,501	767	
	Sump/Pump, Drain and Misc. Equipment	--	15	
French Drain and Partial Excavation	Treatment Plant Equipment	--	20	Would require off-site shipments of contaminated soil to a RCRA disposal facility. Would also involve on-site shipments of contaminated groundwater.
	Treatment Plant Consumables - hydrogen peroxide		2-3 annually	
	Drain Rock	7,334	489	
	Pump, Drain, and Misc. Equipment	--	10	
	Excavation of Contaminated Soil	2,909	200	
	Backfill	2,909	200	
	Collected Contaminated Groundwater	--	6	

Notes: [1] Material volume estimates are based on (Rockwell, 1988a).
[2] Assumes 15-yd^3 capacity for haul trucks and 7,500-gallon tanker trailer capacity for on-site shipments of contaminated water.

Table H-2

COMPARISON OF POTENTIAL TRANSPORTATION IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

Alternative	Transportation Activities During: Construction	Operation	Requires Transport of Contaminated Material: On-Site	Off-Site	Transportation Impacts
Proposed Action	Base Case	Base Case	None	None[1]	Requires approximately 520 truck shipments and occasional receipt of process treatment consumables. No significant transportation impacts result.
No Action	None	None	None	None	Involves no transportation impacts.
Immobilization	Less	None	None	None[1]	A total of 71 truck shipments would be required. Transportation impacts would be negligible.
Total Encapsulation	2nd Highest	None[2]	Yes	None[1]	Requires approximately 460 truck shipments. On-site transfer of contaminated groundwater would also be required -- up to 50 truck shipments initially and one per year subsequentially. No significant transportation impacts would result.
Source Well and Footing Drain Collection with Treatment	Less	Same	None	None[1]	Involves approximately 275 truck shipments and receipt of occasional shipments of process treatment consumables. Transportation impacts would be negligible.
Comprehensive Well Array and Treatment	Less	Same	None	None[1]	Requires approximately 280 truck shipments and periodic receipt of process treatment consumables. Transportation impacts would be negligible.

Notes: [1] If localized radioactivity contamination is found, there may have to be one off-site shipment.

[2] No periodic shipments of process treatment consumables would be required.

Table H-2 (cont.)

COMPARISON OF POTENTIAL TRANSPORTATION IMPACTS OF PROPOSED ACTION AND ALTERNATIVES

Alternative	Transportation Activities During		Requires Transport of Contaminated Material		Transportation Impacts
	Construction	Operation	On-Site	Off-Site	
French Drain and Soil Flushing	More	Slightly Higher	None	None[1]	Involves approximately 802 truck shipments and periodic receipt of process treatment consumables. Incorporation of a leach field increases the number of shipments by 277. No significant transportation impacts would result.
French Drain and Partial Excavation	Highest	Same	Yes	Yes	Requires approximately 925 truck shipments of which 6 would be on-site to transfer contaminated groundwater and 200 would be off-site to dispose of contaminated soil. No significant impacts would result.

APPENDIX I - DISPERSION COEFFICIENTS

Dispersion coefficients (X/Q) were calculated to estimate the concentration of airborne contaminants at points distant from the source of generation on the 881 Hillside Area to be used in estimating the exposure of both RFP site employees not involved in the remedial action and members of the general public. The following formula was used:

$$X/Q = (\pi \times u_{avg} \times \sigma_y \times \sigma_z)^{-1}$$

where:

X/Q = dispersion coefficient (sec/m^3)

π = constant (3.1416....)

u_{avg} = Average wind speed (m/sec)

$\sigma_{y,z}$ = Gaussian distribution coefficients in the crosswind and vertical directions

The average wind speed, u_{avg}, used in the calculation of X/Q was 3 m/sec. This value is significantly lower than the average wind speed of 6 m/sec reported in the Rocky Flats Plant FEIS (DOE, 1980). The lower value for u_{avg} was selected both to make the calculated dispersion coefficients smaller and to be consistent with analyses of other sites with lower average wind speeds than RFP.

The diffusion coefficient calculation for all releases except for accident conditions were calculated using values of σ_y and σ_x calculated using the formulas recommended by Briggs for open-country conditions[1]. The formula for the Pasquill Stability Class D (neutral) was used because that stability class was reported in the FEIS to be the most prevelant, occurring about 52% of the time. The formulas used were as follows:

$$\sigma_y = 0.08X \times (1 + 0.0001X)^{-1/2}$$

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[1]G. A. Briggs, Air Resources Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration, Oak Ridge, Tennessee (Gifford, 1976).

$$\sigma_z = 0.06X \times (1 + 0.0015X)^{-1/2}$$

where X is the downwind distance in meters.

For chronic exposures such as those resulting from construction and operational activities, the average value of X/Q were used in all calculations although it is generally refered to simply as X/Q. The average X/Q is calculated for a given direction and distance from the source by multiplying the calculated value for X/Q by the frequency with which the wind blows in the direction of interest. The calculations used the average annual frequencies reported in the FEIS, Table B-2-5.

The distance from the 881 Hillside site to the nearest plant boundary was estimated for each of the five 22.5-degree sectors from east to south (inclusive). These distances were used to calculate an average X/Q for each of those sectors. Table I-1 lists nearest boundary distance, X/Q, and the average X/Q for each of the selected sectors. The average X/Q with the highest numerical value was used in the calculations of all public exposures except the accident scenario. The value for X/Q for the accident scenario will be discussed in a subsequent paragraph.

The distance from the proposed french drain and the 881 Building was estimated for each of the six 22.5 degree sectors for which the drain comes closest to the building. The average X/Q was calculated for each of these sectors at the closest distance in that sector. Table I-1 lists the results of these calculations. The average X/Q with the highest numeric value was used in the calculations to estimate the exposure of site employees during construction activities.

Buildings were identified which might be expected to be continuously occupied, either currently or in the future, which were closest to the proposed site of the waste treatment facility. For each, the downwind direction and distance from the proposed site of the water treatment facility were identified and the average X/Q calculated. The results of these calculations are listed in Table I-1. The average X/Q with the highest numeric value was used in calculations of exposures of site employees to operational releases from the water treatment facility. Releases during the accident scenario will be discussed in a subsequent paragraph.

The values for X/Q used in the accident scenario calculations were calculated differently than those for chronic exposures. No credit was taken for average wind frequencies.

The distance to the closest boundary was estimated to calculate a X/Q for the public and the distance to the closest occupied or potentially occupied onsite building was used to calculate the X/Q for site employees. The closest boundary is directly south of the 881 remediation site and is 1980 meters from the estimated location of the new water treatment facility. The closest occupied building is the 881 Building, which was assumed to be about 46 meters west of the location of the new water treatment facility. Even though the annual average frequency of wind for these two directions is very low and the two locations selected are in very different directions, it was assumed for the calculations that the wind was blowing constantly toward those locations throughout the full twenty-four hours following the accident.

The formula used to calculate the short-term dispersion coefficients was also modified. It was assumed that a Pasquill Stability Class of F would prevail. The values for σ_y and σ_z were calculated using formulas designed to account for short-term diffusion characteristics as follows[2]:

$$\sigma_y = 0.02 \times X^{0.89}$$

$$\sigma_z = 0.05 \times X^{0.61}$$

The value of X/Q calculated at 1,980 meters with an average wind velocity was 4.57 E-5 seconds per cubic meter. The value of X/Q for the 881 Building with an average wind velocity was 2.05 E-2 seconds per cubic meter.

[2](Slade, 1968)

Table I-1

DISPERSION COEFFICIENTS (X/Q) FOR CONSTRUCTION AND OPERATION ACTIVITIES

Identifier	Downwind Direction	Downwind Distance (meters)	Average Annual Frequency	X/Q	Average X/Q
--	E	2,900	0.107	6.90 E-6[1]	7.39 E-7
--	ESE	3,200	0.131	5.97 E-6	7.82 E-7
--	SE	2,820	0.102	7.20 E-6	7.34 E-7
--	SSE	2,130	0.081	1.10 E-5	8.90 E-7 *
--	S	1,980	0.066	1.23 E-5	8.12 E-7
881 Building	W	46	0.019	1.10 E-2	2.08 E-4 *
883 Building	NW	152	0.056	1.06 E-3	5.95 E-5
865 Building	N	198	0.028	6.48 E-4	1.81 E-5
886 Building	NNE	198	0.029	6.48 E-4	1.88 E-5
991 Building	NE	610	0.069	8.48 E-5	5.85 E-6
Trench to 881 Building	NE	152	0.69	1.06 E-3	7.33 E-5 *
"	NNE	152	0.029	1.06 E-3	3.08 E-5
"	N	137	0.028	1.30 E-3	3.64 E-5
"	NNW	152	0.039	1.06 E-3	4.15 E-5
"	NW	168	0.056	8.87 E-4	4.97 E-5
"	WNW	229	0.030	4.96 E-4	1.49 E-5

* X/Q selected for use in calculation. See text for details.

[1] 6.90 E-6 = 6.90×10^{-6} = 0.0000069

APPENDIX J - RISKS FROM INADVERTENT INGESTION

The term inadvertent ingestion as applied in this report involves the transfer of contaminated soil from skin surfaces to oral intake or direct ingestion of soil by the subject. In the case of remediation workers, both protective measures, such as special clothing, and special training to familiarize the workers with the hazards involved with working in potentially contaminated soil will tend to decrease the likelihood of such ingestion. The Risk Assessment (Rockwell, 1988b) assumed an uptake of 25 mg/day of soil for members of the public living on contaminated soil without taking any protective measures or being aware of the hazards. For this analysis, it is assumed that the special protective measures and training reduce the daily intake to 20% of that assumed in the Risk Assessment. The chronic daily intake for remedial workers is calculated by the following equation:

$$CDI = (C_{soil} \times IR \times K)/BW$$

where:

CDI	=	Chronic Daily Intake
C_{soil}	=	Concentration of the contaminant of interest in the soil in mg/kg
IR	=	Ingestion Rate of contaminated soil
	=	5 mg/day
K	=	Units correction factor
	=	10^{-6} kg/mg
BW	=	Body Weight
	=	70 kg

The analysis of risks involved in the intakes as calculated above is performed as described in Appendix A.

Analysis was performed on bis-(2-ethylhexyl)phthalate (DEHP), the only low-volatility organic chemical of interest, as well as on manganese, mercury, nickel, and selenium, the metals that were reported as exceeding ARARs in water samples. Average levels of these metals were determined from the chemical analysis of soil taken from the boreholes nearest the proposed location of the french drain trench as reported in the Remedial Investigation Report (Rockwell, 1988c). The oral values for PF and HEC listed in Table A-1 for these materials were used in the analysis of risks. Only the results for mercury and nickel are reported because no soil samples yielded results for manganese or selenium which were greater than the minimum detectable limit.

Since values for the RfD and PF have not been published for uranium or plutonium for oral intakes, the assessment of risk was performed by calculating the fifty-year committed effective dose equivalent (CEDE) for each of the radionuclides by multiplying the total activity intake by its ingestion dose conversion factor (EPA, 1988). The total uptake was calculated by the following formula:

$$I = CDI \times EDA$$

where:

I	=	Total oral intake from inadvertent ingestion
CDI	=	Chronic Daily Intake as defined earlier
EDA	=	Exposure Duration Adjustment (number of days worked)
	=	60

Table J-1 shows the results of the risk evaluations.